



US010944443B2

(12) **United States Patent**
Wang et al.

(10) **Patent No.:** **US 10,944,443 B2**
(45) **Date of Patent:** **Mar. 9, 2021**

(54) **PORTABLE ELECTRONIC DEVICE WITH TWO-PIECE HOUSING**

(71) Applicants: **Apple Inc.**, Cupertino, CA (US); **BJ Watrous**, Menlo Park, CA (US)

(72) Inventors: **Erik L. Wang**, Redwood City, CA (US); **Phillip Michael Hobson**, Menlo Park, CA (US); **Kenneth A. Jenks**, Capitola, CA (US); **Adam D. Mittleman**, Portola Valley, CA (US); **Bartley K. Andre**, Palo Alto, CA (US); **Daniel J. Coster**, San Francisco, CA (US); **Daniele De Iuliis**, San Francisco, CA (US); **Richard P. Howarth**, San Francisco, CA (US); **Jonathan P. Ive**, San Francisco, CA (US); **Steven P. Jobs**, Palo Alto, CA (US); **Duncan Robert Kerr**, San Francisco, CA (US); **Shin Nishibori**, Kailua, HI (US); **Matthew Dean Rohrbach**, San Francisco, CA (US); **Douglas B. Satzger**, Menlo Park, CA (US); **Calvin Q. Seid**, Palo Alto, CA (US); **Christopher J. Stringer**, Woodside, CA (US); **Eugene Anthony Whang**, San Francisco, CA (US); **Rico Zorkendorfer**, San Francisco, CA (US)

(73) Assignee: **Apple Inc.**, Cupertino, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **16/718,627**

(22) Filed: **Dec. 18, 2019**

(65) **Prior Publication Data**
US 2020/0127697 A1 Apr. 23, 2020

Related U.S. Application Data

(60) Continuation of application No. 15/098,742, filed on Apr. 14, 2016, now Pat. No. 10,594,351, which is a (Continued)

(51) **Int. Cl.**
G06F 1/16 (2006.01)
H05K 5/00 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H04B 1/3888** (2013.01); **G06F 1/1626** (2013.01); **G06F 1/1637** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC G06F 1/1626; G06F 1/1637; G06F 1/1656; G06F 1/1658; H04B 1/3888;
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,414,902 A 12/1968 Shaw, Jr.
3,453,377 A 7/1969 Gillespie
(Continued)

FOREIGN PATENT DOCUMENTS

CN 1349704 5/2002
CN 1788422 6/2006
(Continued)

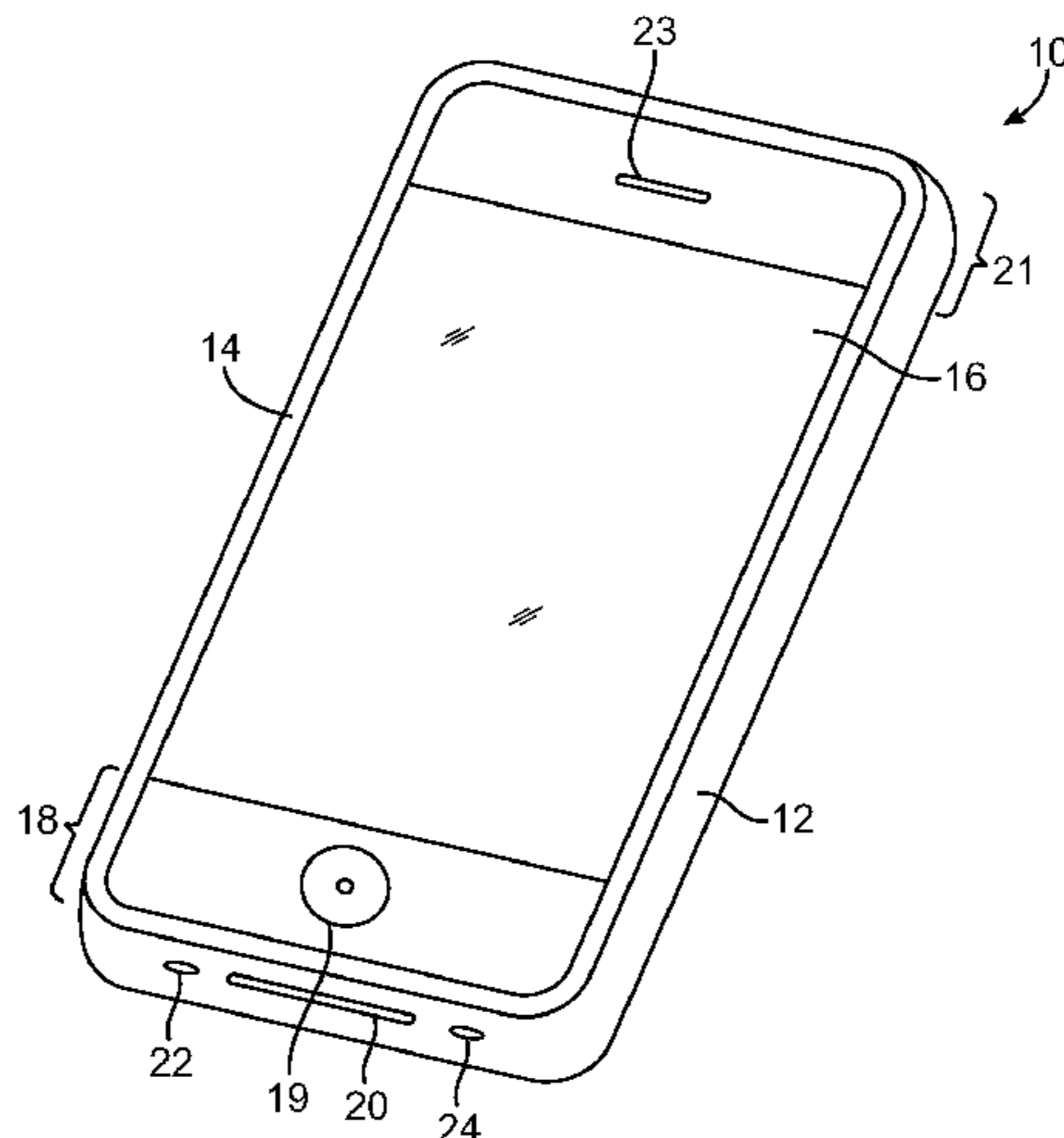
OTHER PUBLICATIONS

Hobson et al. U.S. Appl. No. 60/883,537, filed Jan. 5, 2007.
(Continued)

Primary Examiner — Anthony M Haughton
(74) *Attorney, Agent, or Firm* — Treyz Law Group, P.C.; G. Victor Treyz; Kendall W. Abbasi

(57) **ABSTRACT**

Portable electronic devices are provided. Each device may be formed from two parts. A first part may be provided with
(Continued)



components such as a display, a touch screen, a cover glass, and a frame. A second part may be provided with a plastic housing, circuit boards containing electrical components, and a bezel. Engagement members may be connected to the first and second parts. The engagement members may be formed from metal clips with holes and springs with flexible spring prongs that mate with the holes in the clips. The metal clips may be welded to frame struts on the frame and the springs may be welded to the bezel. During assembly, the first part may be rotated into place within the second part. Retention clips attached to the frame may be used to secure the two parts together. Assembly instructions and associated connector numbers may be provided within the devices.

20 Claims, 28 Drawing Sheets

Related U.S. Application Data

continuation of application No. 13/525,725, filed on Jun. 18, 2012, now Pat. No. 9,344,539, which is a continuation of application No. 13/084,490, filed on Apr. 11, 2011, now abandoned, which is a division of application No. 12/119,986, filed on May 13, 2008, now Pat. No. 7,933,123.

- (60) Provisional application No. 61/044,445, filed on Apr. 11, 2008.
- (51) **Int. Cl.**
H05K 7/00 (2006.01)
H04B 1/3888 (2015.01)
H04M 1/02 (2006.01)
- (52) **U.S. Cl.**
 CPC *G06F 1/1656* (2013.01); *G06F 1/1658* (2013.01); *H04M 1/026* (2013.01); *H04M 1/0252* (2013.01); *H04M 1/0266* (2013.01); *H04M 1/0274* (2013.01); *H04M 1/0277* (2013.01); *H04M 2250/22* (2013.01); *Y10T 29/49002* (2015.01)
- (58) **Field of Classification Search**
 CPC .. H04M 1/0252; H04M 1/026; H04M 1/0274; H04M 1/0277
 See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,546,365	A	12/1970	Collier
3,573,628	A	4/1971	Cramer, Jr.
3,858,019	A	12/1974	Muri et al.
4,127,752	A	11/1978	Lowthorp
4,636,698	A	1/1987	Leclercq
4,721,945	A	1/1988	Maki et al.
4,723,305	A	2/1988	Phillips et al.
D296,440	S	6/1988	Smith et al.
4,894,663	A	1/1990	Urbish
4,973,259	A	11/1990	Sachs
4,980,694	A	12/1990	Hines
5,021,010	A	6/1991	Wright
D319,050	S	8/1991	Korellis et al.
5,041,838	A	8/1991	Liimantainen
5,048,118	A	9/1991	Brooks
5,051,543	A	9/1991	McGuire
5,061,827	A	10/1991	Grabbe
5,181,044	A	1/1993	Matsumoto et al.
5,217,392	A	6/1993	Hosler
5,231,381	A	7/1993	Duwaer

5,278,351	A	1/1994	Herrick
5,379,182	A	1/1995	Fujimori
5,383,098	A	1/1995	Ma et al.
5,393,244	A	2/1995	Szegda
5,408,699	A	4/1995	Yamashita et al.
D360,195	S	7/1995	Kimbrough et al.
D361,731	S	8/1995	Stegar
5,473,117	A	12/1995	Morgan et al.
5,561,437	A	10/1996	Phillips
D380,783	S	7/1997	Tyler
5,650,834	A	7/1997	Nakagawa
D382,603	S	8/1997	Goto
5,713,466	A	2/1998	Tajima
5,754,143	A	5/1998	Warnagiris
D396,452	S	7/1998	Naruki
5,777,583	A	7/1998	Canora
5,798,984	A	8/1998	Koch
5,905,550	A	5/1999	Ohgami et al.
5,982,355	A	11/1999	Jaeger
6,005,208	A	12/1999	Castonguay
6,011,699	A	1/2000	Murray
D421,972	S	3/2000	Makidera et al.
6,097,345	A	8/2000	Walton
6,160,701	A	12/2000	Baker et al.
6,171,138	B1	1/2001	Lefebvre et al.
D437,594	S	2/2001	Goldberg et al.
6,190,202	B1	2/2001	Lai
6,194,653	B1	2/2001	McMiller et al.
6,219,230	B1	4/2001	Cho
D442,172	S	5/2001	Mizuno
6,266,240	B1	7/2001	Urban et al.
6,285,327	B1	9/2001	See
6,308,084	B1	10/2001	Lonka
D451,505	S	12/2001	Iseki et al.
D452,250	S	12/2001	Chan
D453,158	S	1/2002	Chen
6,337,662	B1	1/2002	Cassel
6,375,026	B1	4/2002	Sheldrake et al.
6,430,039	B2	8/2002	Nakajima et al.
6,469,668	B1	10/2002	Jones et al.
6,477,061	B1	11/2002	Johnson
6,483,719	B1	11/2002	Bachman
D470,523	S	2/2003	Basmadjian et al.
6,532,152	B1	3/2003	White et al.
6,542,128	B1	4/2003	Johnson et al.
6,545,624	B2	4/2003	Doub et al.
6,545,642	B1	4/2003	Doub et al.
6,574,098	B2	6/2003	Netzel et al.
6,594,472	B1	7/2003	Curtis et al.
6,622,031	B1	9/2003	McCleary
D480,720	S	10/2003	Sjoberg et al.
6,670,923	B1	12/2003	Kadambi
D485,265	S	1/2004	Sato et al.
D486,133	S	2/2004	Martinez et al.
6,714,778	B2	3/2004	Nykanen
D489,063	S	4/2004	Chiu et al.
D490,418	S	5/2004	Liao
6,741,214	B1	5/2004	Kadambi
6,747,601	B2	6/2004	Boyle
D494,188	S	8/2004	Huang
6,790,092	B2	9/2004	Parsadayan et al.
6,808,239	B1	10/2004	Bader
6,809,265	B1	10/2004	Gladd
D498,754	S	11/2004	Blyth
6,835,923	B2	12/2004	Hämäläinen et al.
6,842,633	B1	1/2005	Deo et al.
D501,476	S	2/2005	Quijano
6,856,294	B2	2/2005	Kadambi
D502,945	S	3/2005	Huang et al.
D506,195	S	6/2005	Leveridge et al.
D507,267	S	7/2005	Loew et al.
6,915,120	B2	7/2005	Ichihara
6,931,125	B2	8/2005	Smallwood
6,968,508	B2	11/2005	Lucaci
6,980,154	B2	12/2005	Vance
D514,568	S	2/2006	Huang et al.
D516,550	S	3/2006	Taniho et al.
7,009,567	B2	3/2006	Iwai et al.
7,013,558	B2	3/2006	Bachman

(56)

References Cited

U.S. PATENT DOCUMENTS

D519,502 S 4/2006 Hawkins et al.
 7,027,838 B2 4/2006 Zhou
 D520,020 S 5/2006 Senda et al.
 D527,015 S 8/2006 Yang
 D528,542 S 9/2006 Luminosu et al.
 7,106,392 B2 9/2006 You
 7,110,797 B2 9/2006 Soejima
 7,116,267 B2 10/2006 Schuster et al.
 7,119,747 B2 10/2006 Lin
 7,153,161 B2 12/2006 Huang
 D536,337 S 2/2007 Chuang
 7,181,172 B2 2/2007 Sullivan et al.
 7,202,825 B2 4/2007 Leizerovich et al.
 7,271,772 B2 9/2007 Qi et al.
 7,280,100 B2 10/2007 Hanson
 7,292,193 B2 11/2007 Jang
 7,292,290 B2 11/2007 Miyagawa et al.
 D557,243 S 12/2007 Kim et al.
 7,304,837 B2 12/2007 Lo et al.
 D558,726 S 1/2008 Wang et al.
 D560,229 S 1/2008 Yagi
 D560,230 S 1/2008 Yagi
 D561,204 S 2/2008 Toh
 D561,782 S 2/2008 Kim
 7,339,528 B2 3/2008 Wang
 D565,596 S 4/2008 Kim
 D567,254 S 4/2008 Lee
 D568,310 S 5/2008 Franck et al.
 D573,144 S 7/2008 Lin
 7,400,302 B2 7/2008 Winter
 D577,705 S 9/2008 Marquez
 7,438,610 B2 10/2008 Machado
 7,467,001 B2 12/2008 Wu
 7,499,037 B2 3/2009 Lube
 D590,825 S 4/2009 Liu
 7,558,054 B1 7/2009 Prest et al.
 D599,345 S 9/2009 Ko et al.
 7,595,759 B2 9/2009 Schlub et al.
 7,639,187 B2 12/2009 Caballero
 D610,141 S 2/2010 Griffin et al.
 7,663,878 B2 2/2010 Swan et al.
 7,688,267 B2 3/2010 Hill
 7,688,315 B1 3/2010 Gettemy et al.
 7,688,574 B2 3/2010 Zadesky et al.
 7,711,400 B2 5/2010 Nuovo
 7,876,274 B2 1/2011 Hobson et al.
 7,889,139 B2 2/2011 Hobson et al.
 7,911,387 B2 3/2011 Hill et al.
 8,014,142 B2 9/2011 Prest et al.
 8,060,168 B2 11/2011 Horrdin et al.
 8,339,250 B2 12/2012 Je et al.
 8,634,884 B2 1/2014 Kim et al.
 8,681,056 B2 3/2014 Hobson et al.
 9,001,047 B2 4/2015 Forstall et al.
 2001/0002145 A1 5/2001 Lee et al.
 2002/0022979 A1 2/2002 Whipp et al.
 2002/0056142 A1 5/2002 Redmond
 2002/0082079 A1 6/2002 Mantyjarvi
 2002/0132521 A1 9/2002 Groebe et al.
 2003/0020679 A1 1/2003 Kojima et al.
 2003/0160754 A1 8/2003 Hanson et al.
 2004/0145521 A1 7/2004 Hebron
 2004/0156168 A1 8/2004 LeVasseur et al.
 2004/0174665 A1 9/2004 Mockridge et al.
 2004/0203511 A1 10/2004 Zheng et al.
 2004/0263359 A1 12/2004 Hampton et al.
 2005/0052329 A1 3/2005 Tsukamoto
 2006/0112969 A1 1/2006 Bachman
 2006/0046792 A1 3/2006 Hassemer et al.

2006/0055606 A1 3/2006 Boyle
 2006/0087835 A1 4/2006 Sevack et al.
 2006/0148425 A1 7/2006 Carlson
 2006/0160411 A1 7/2006 Lai et al.
 2006/0205446 A1 9/2006 Lee et al.
 2006/0231818 A1 10/2006 Lube
 2006/0244663 A1 11/2006 Fleck et al.
 2007/0000764 A1 1/2007 Bellows et al.
 2007/0002535 A1 1/2007 Kim
 2007/0052100 A1 3/2007 Bellinger
 2007/0120878 A1 5/2007 Hsiao et al.
 2007/0123322 A1 5/2007 Mizushina
 2007/0155436 A1 7/2007 Wu
 2007/0293282 A1 12/2007 Lewis et al.
 2008/0012774 A1 1/2008 Wang
 2008/0037771 A1 2/2008 Black et al.
 2008/0074329 A1 3/2008 Caballero
 2008/0146293 A1 6/2008 Kim
 2008/0166004 A1 7/2008 Sanford
 2008/0176359 A1 7/2008 Molkkari et al.
 2008/0261109 A1 10/2008 Shieh et al.
 2008/0316115 A1* 12/2008 Hill H01Q 1/48
 343/702
 2009/0033562 A1 2/2009 Takeuchi et al.
 2009/0059485 A1 3/2009 Lynch et al.
 2009/0064038 A1 3/2009 Fleischman et al.
 2009/0131129 A1 5/2009 Yamazaki et al.
 2009/0195974 A1 8/2009 Rambosek et al.
 2009/0247237 A1* 10/2009 Mittleman H04M 1/0202
 455/567
 2014/0132463 A1 5/2014 Hobson et al.
 2014/0233168 A1 8/2014 Hobson et al.
 2014/0233169 A1 8/2014 Hobson et al.
 2014/0233170 A1 8/2014 Hobson et al.
 2014/0243052 A1 8/2014 Hobson et al.

FOREIGN PATENT DOCUMENTS

CN 1964374 5/2007
 CN 101005664 7/2007
 CN 101047728 10/2007
 EP 1286413 2/2003
 EP 1569079 8/2005
 EP 1603308 12/2005
 EP 1478161 3/2006
 EP 1884870 2/2008
 JP 2006073599 3/2006
 JP 2006303911 11/2006
 JP 2007142745 6/2007
 JP 2007226285 9/2007
 JP 2008027183 2/2008
 KR 3004523050000 6/2007
 KR 100 810 266 3/2008
 WO 2007091600 8/2007

OTHER PUBLICATIONS

Guttenburg, S., CNET.com Review of Cambridge Soundworks Radio 730, 5 pages, Reviewed Jun. 3, 2003.
 Cambridge Soundworks 430 Radio User Manual, 16 pages, Cambridge Soundworks, 2003.
 Toshiba: "Service Manual Color Television 13A21 C", Jun. 4, 2001 (Jun. 4, 2001), XP55178347, Retrieved from the Internet: <URL: http://pdfstream.manualsonline.com/c/ce82031_b-b808-4dcb-bc8a-7_1_ab4db209b6.pdf> [retrieved on Mar. 23, 2015].
 Anonymous: "iPhone—Wikipedia", Apr. 9, 2008 (Apr. 9, 2008), XP55635941, Retrieved from the internet: URL:<https://en.wikipedia.org/w/index.php?title=iPhone&oldid=204447410> [retrieved on Oct. 25, 2019].

* cited by examiner

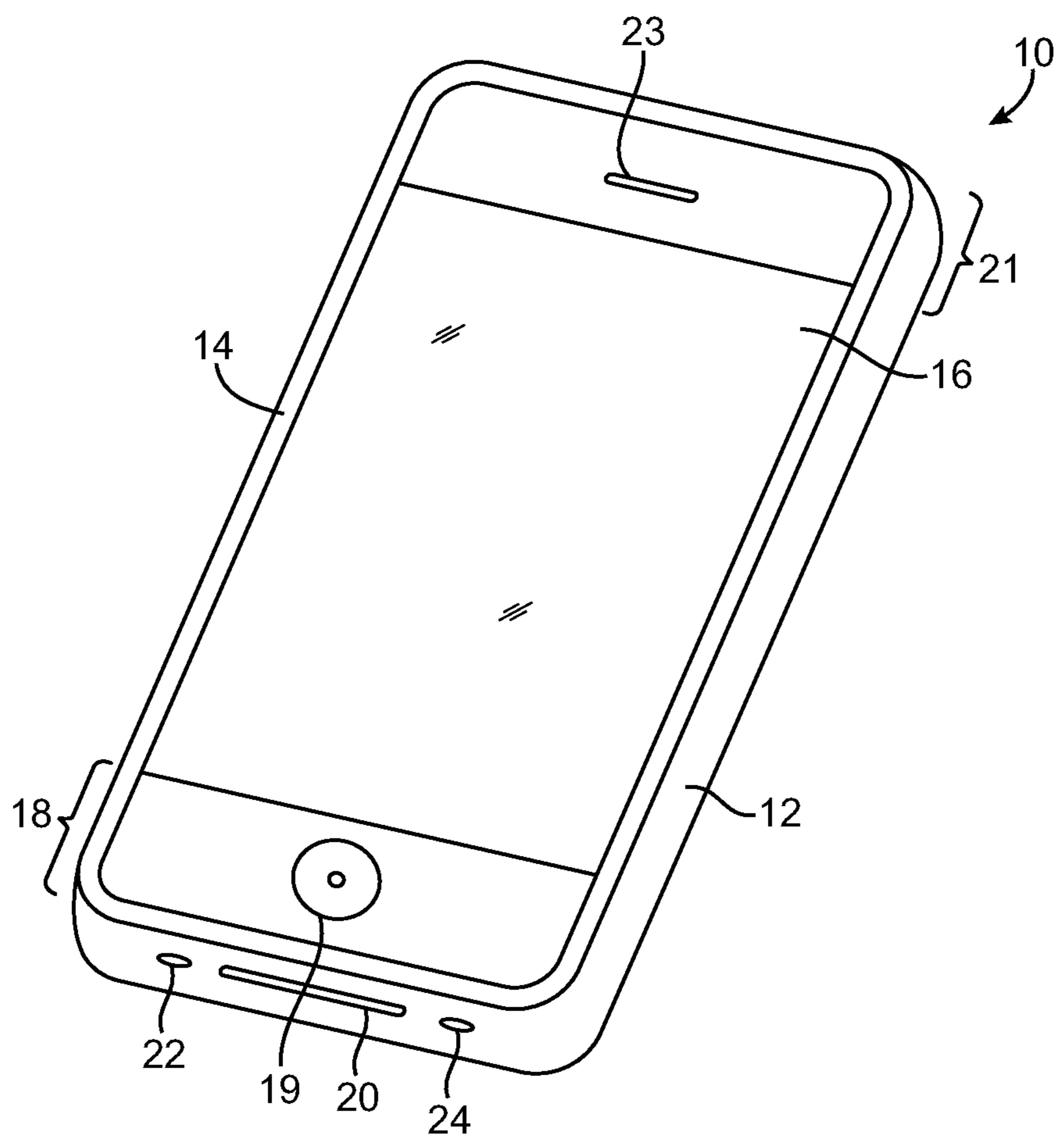


FIG. 1

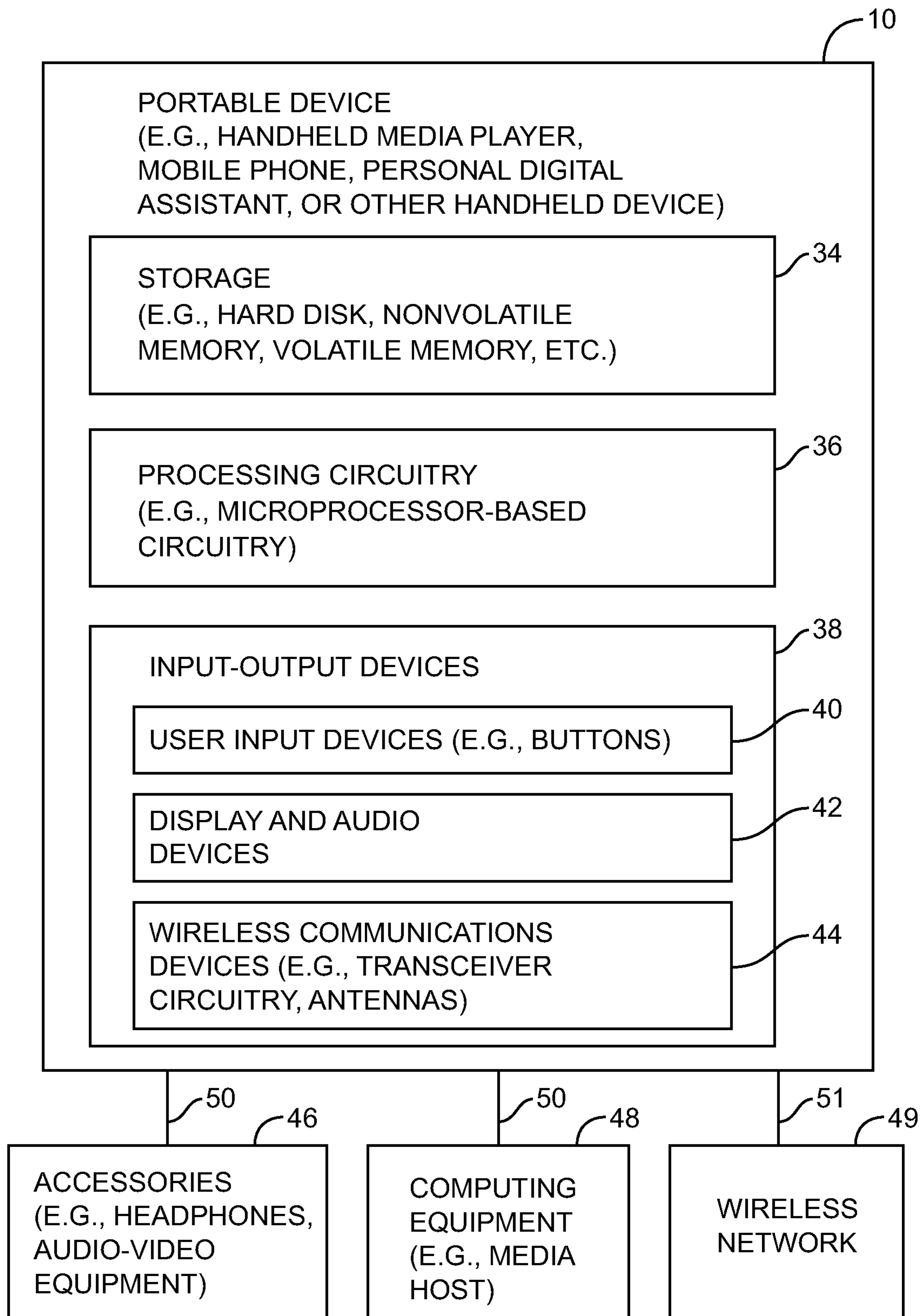


FIG. 2

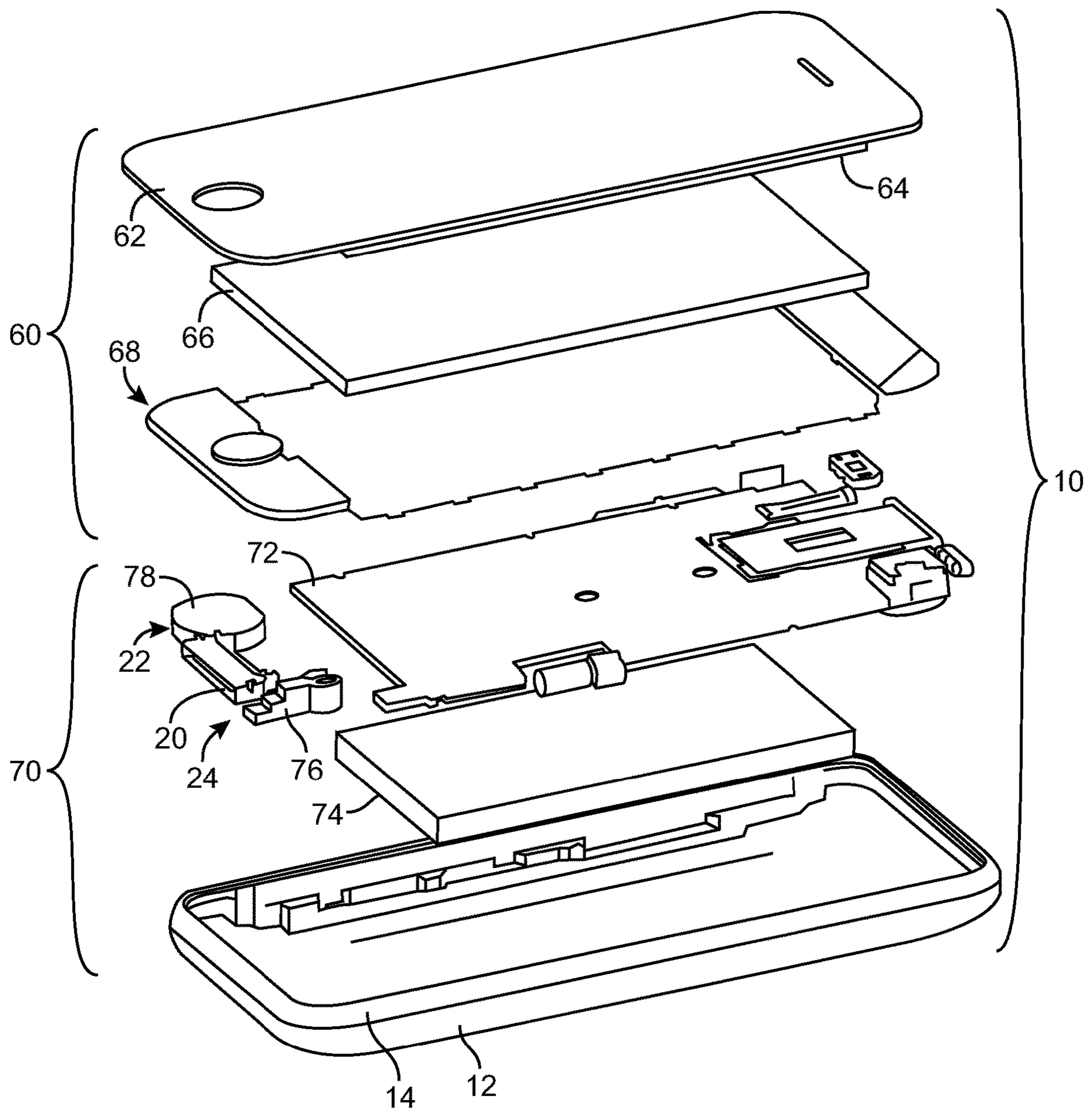


FIG. 3

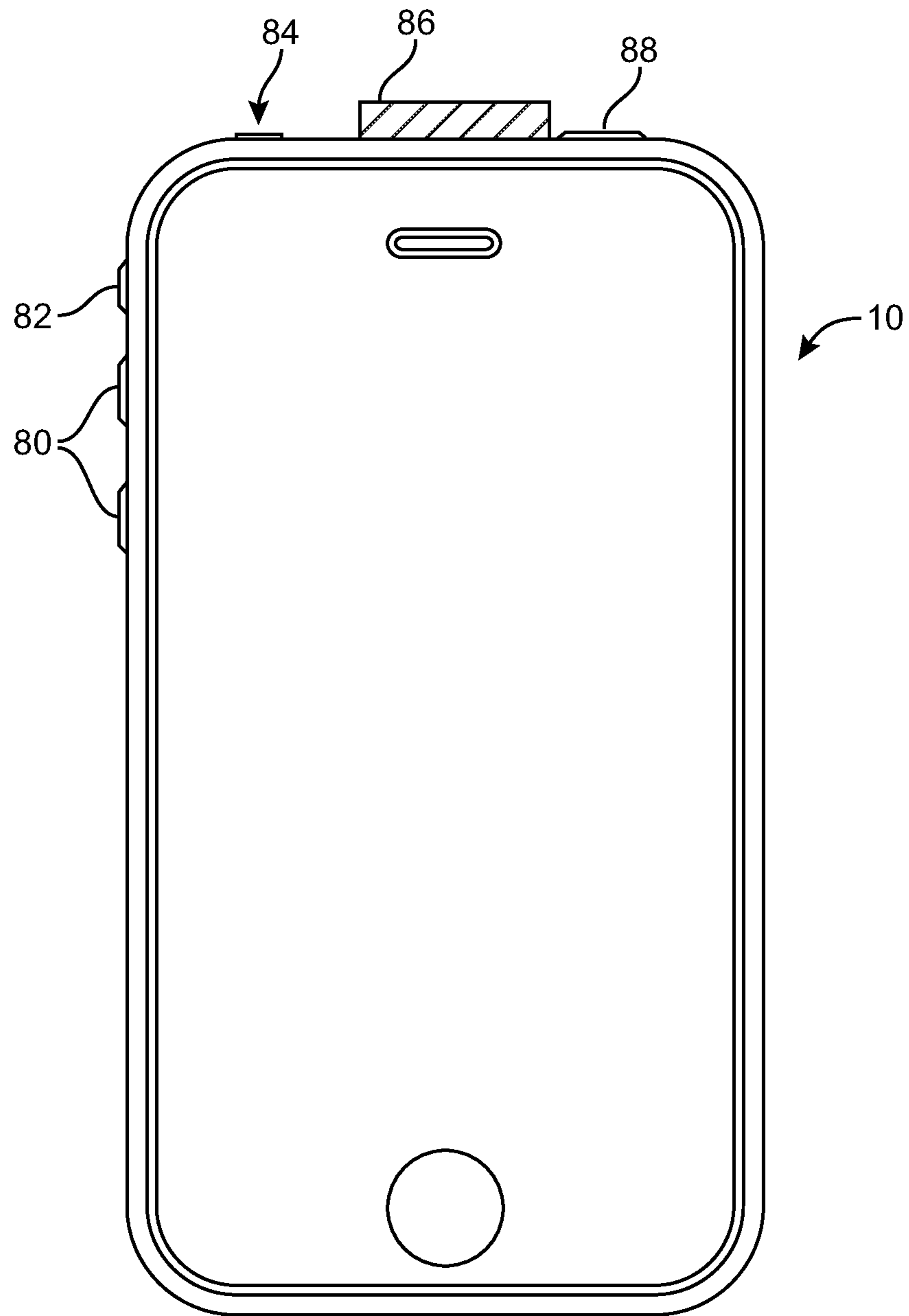


FIG. 4

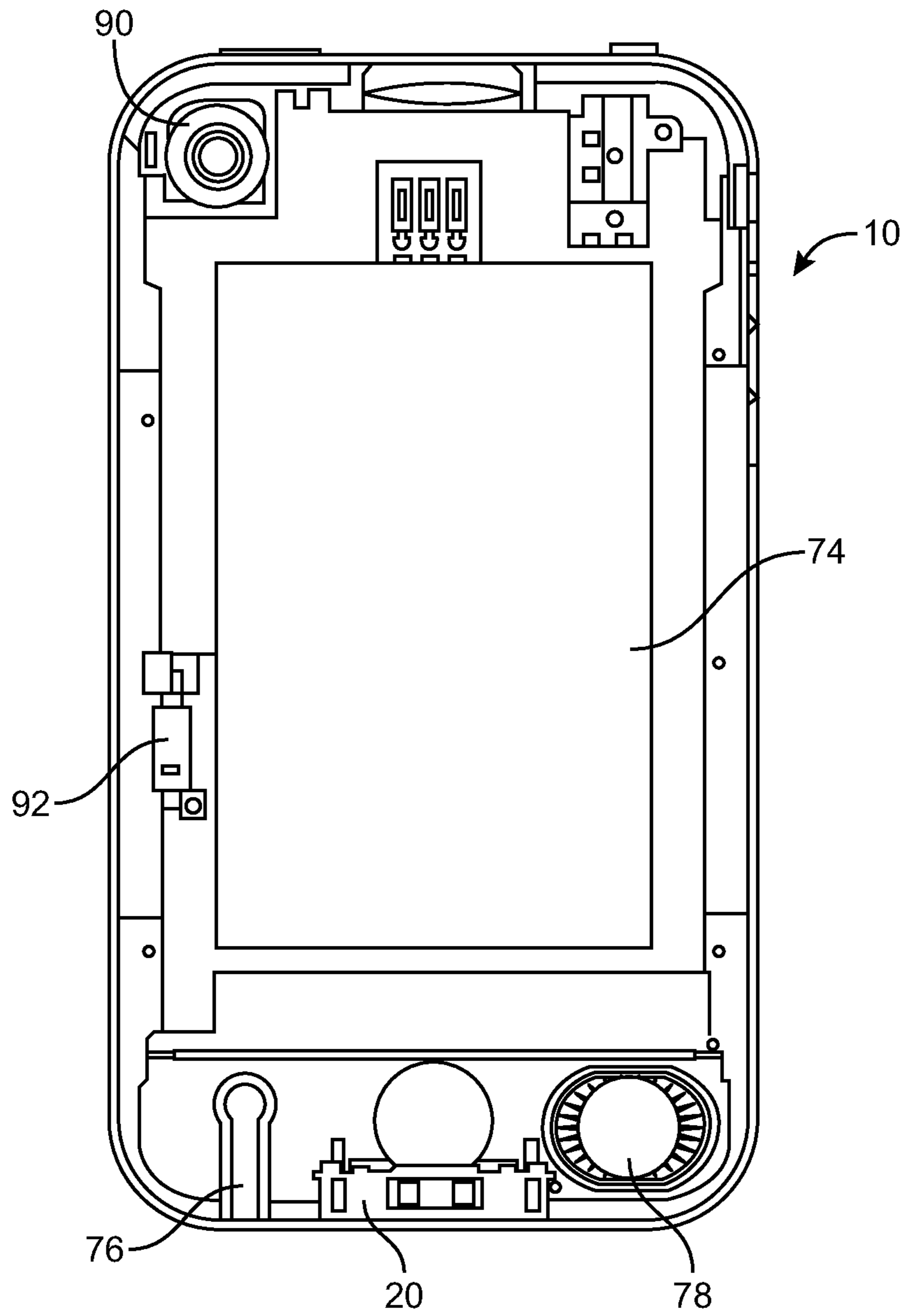


FIG. 5

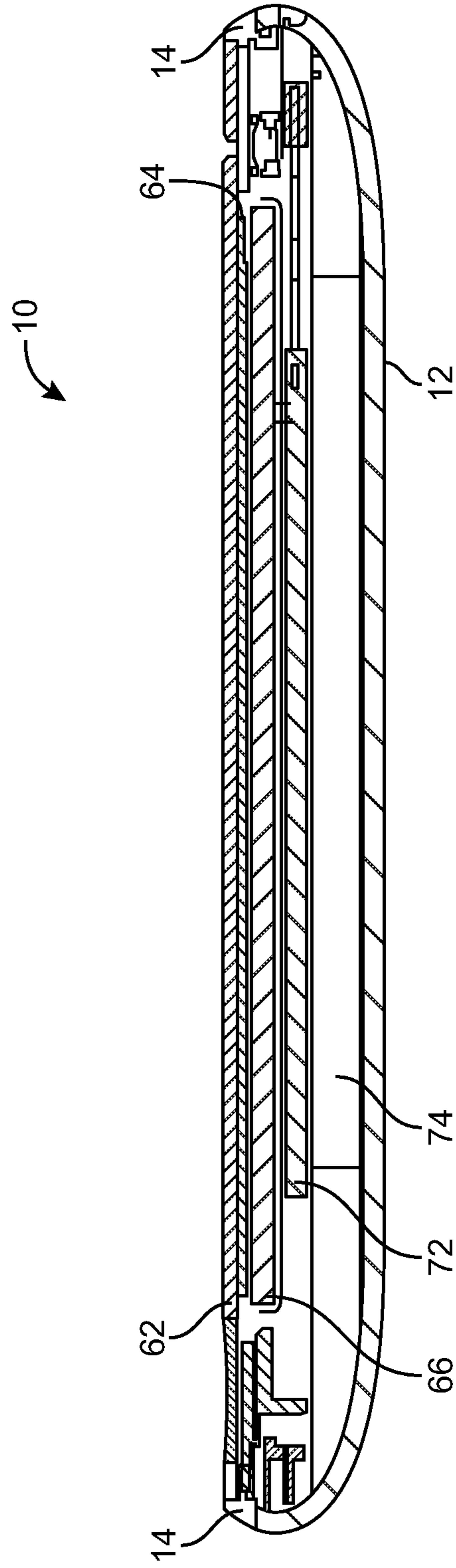


FIG. 6

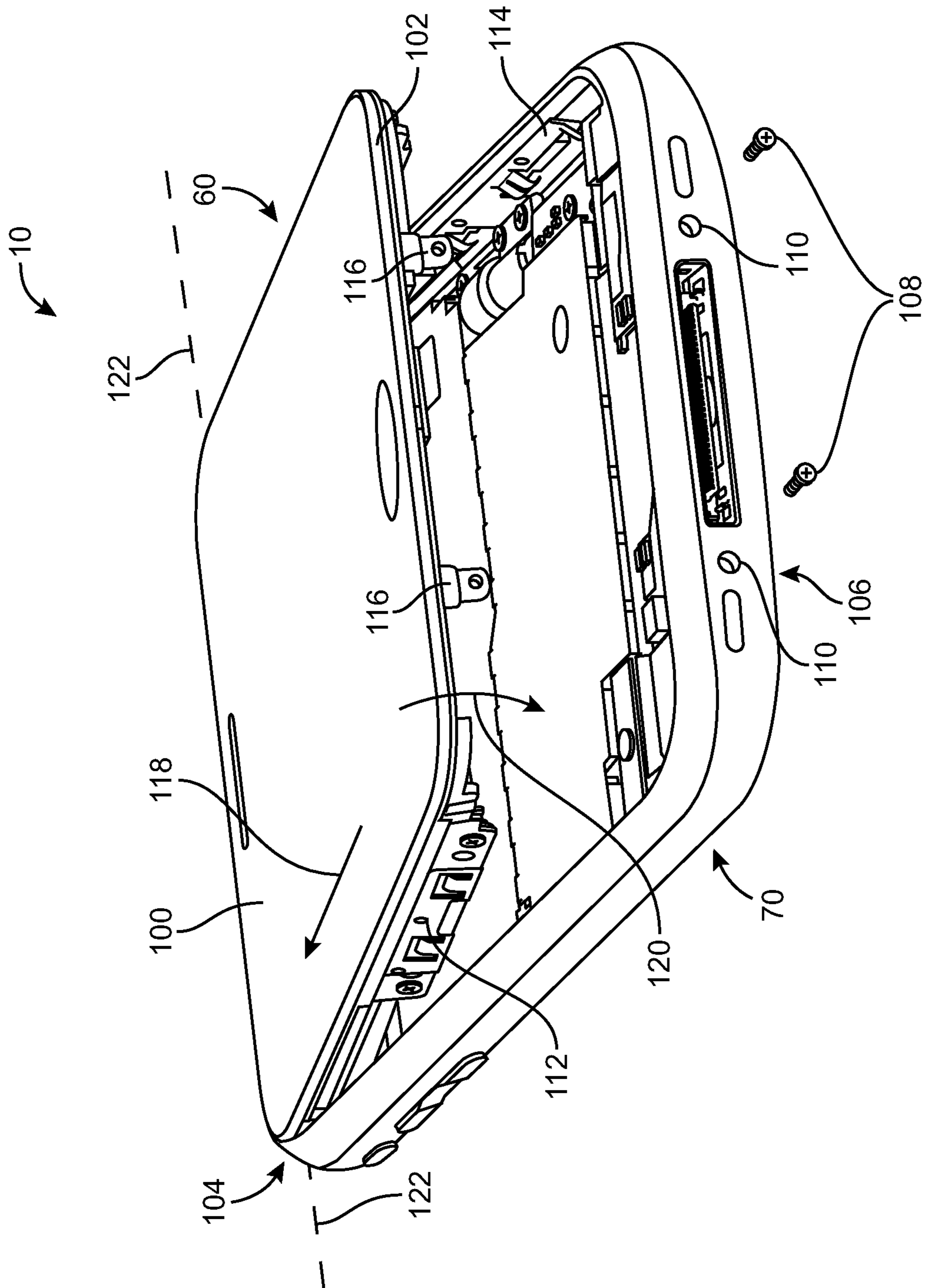


FIG. 7

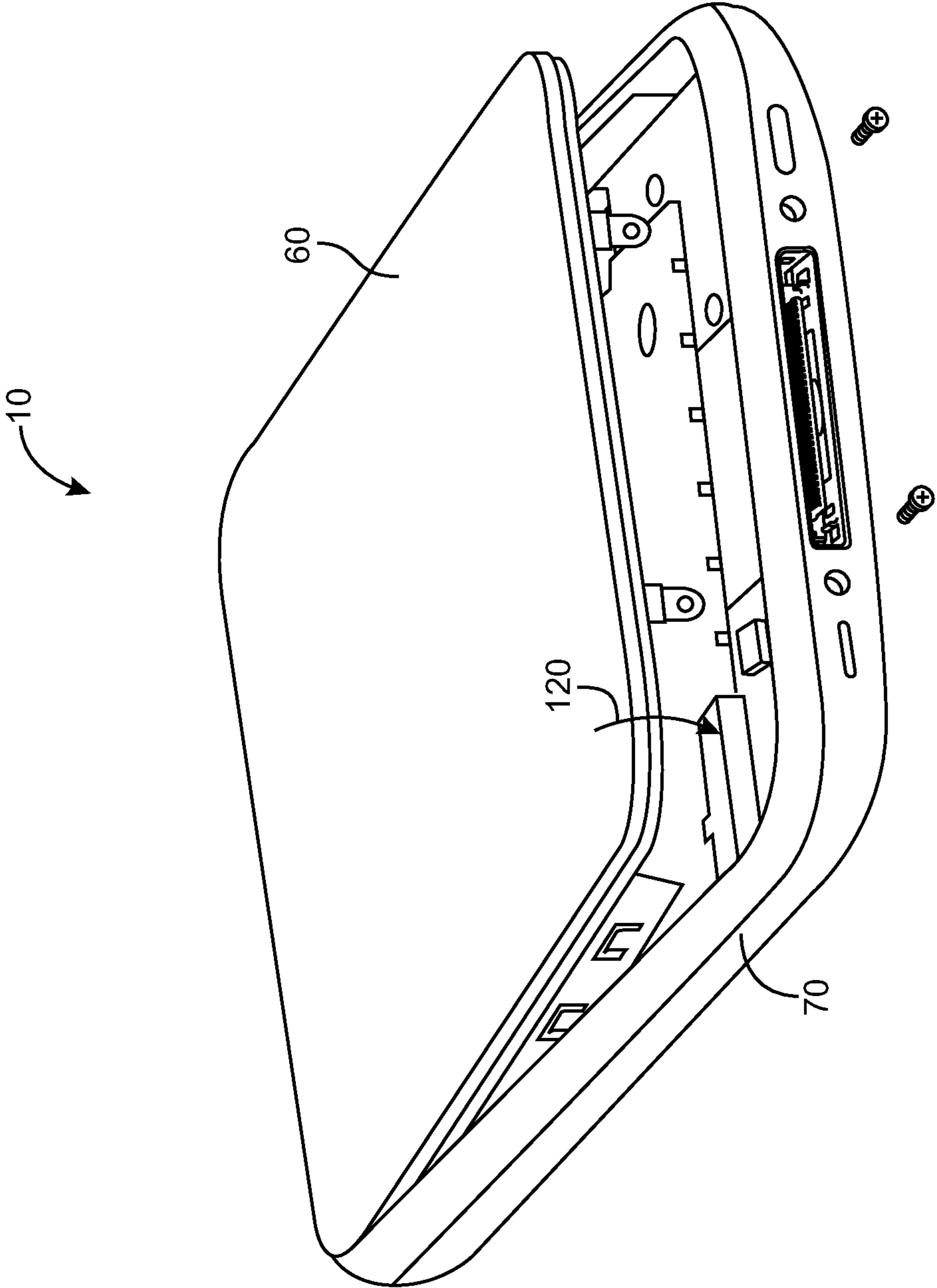


FIG. 8

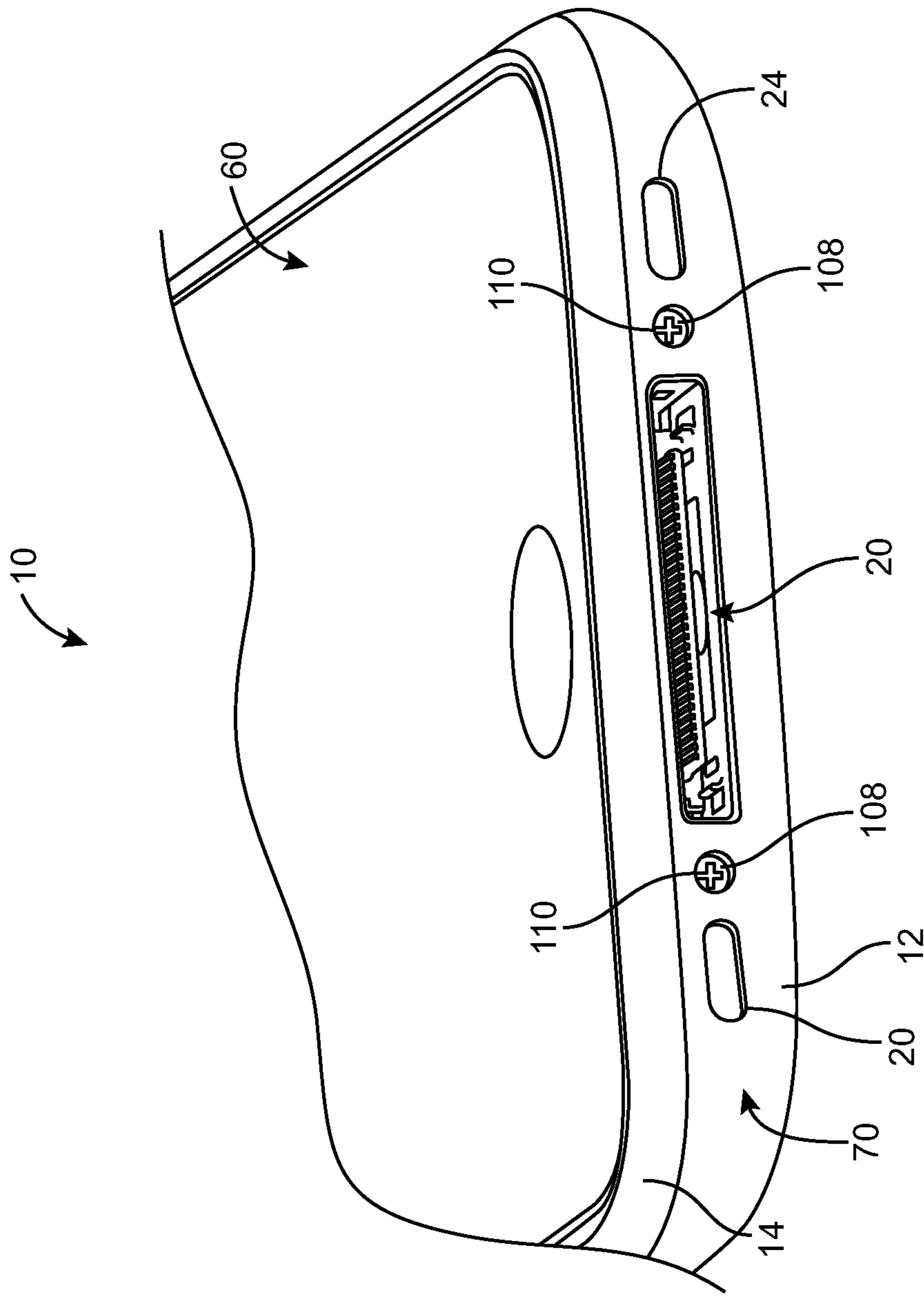
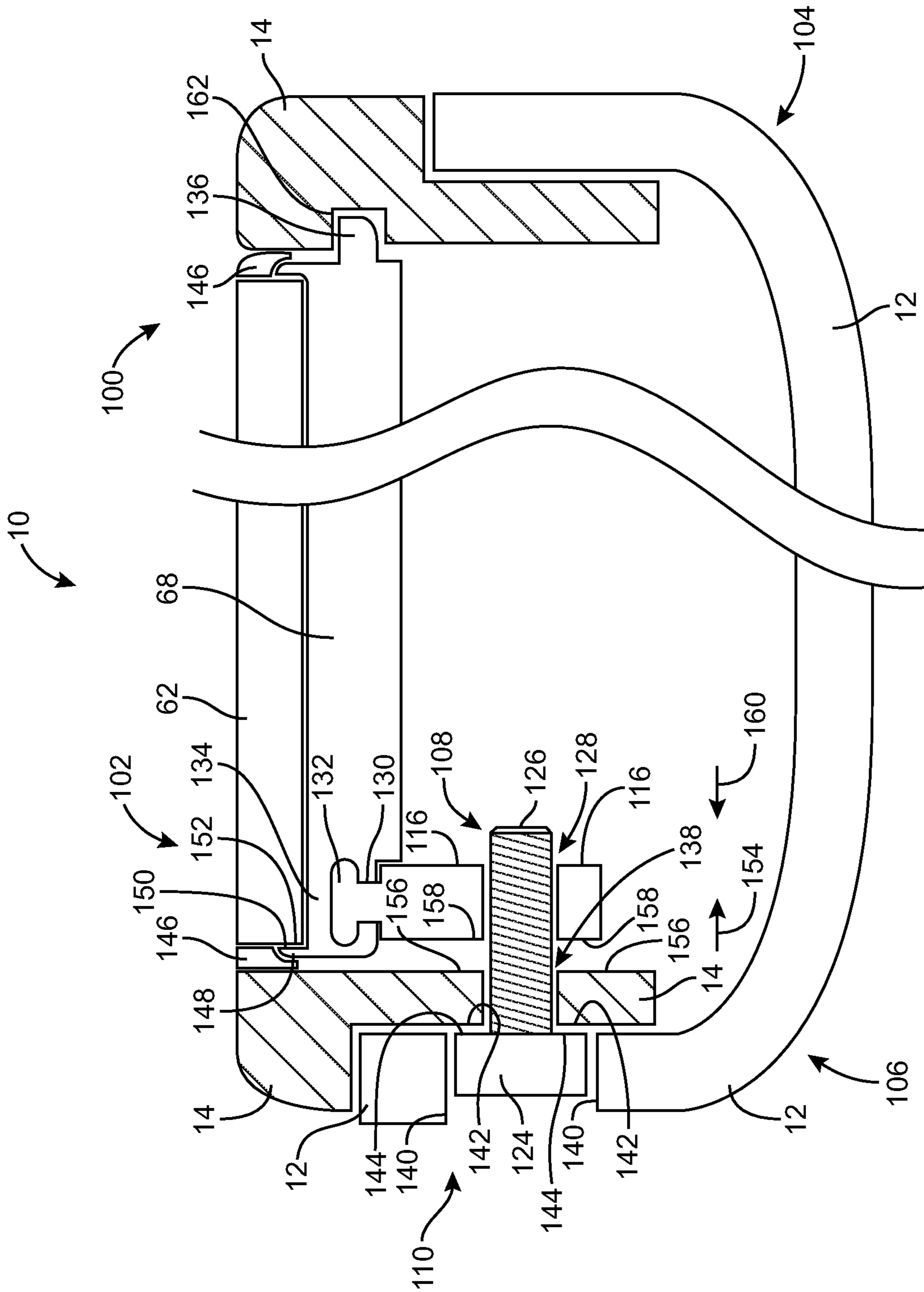


FIG. 9



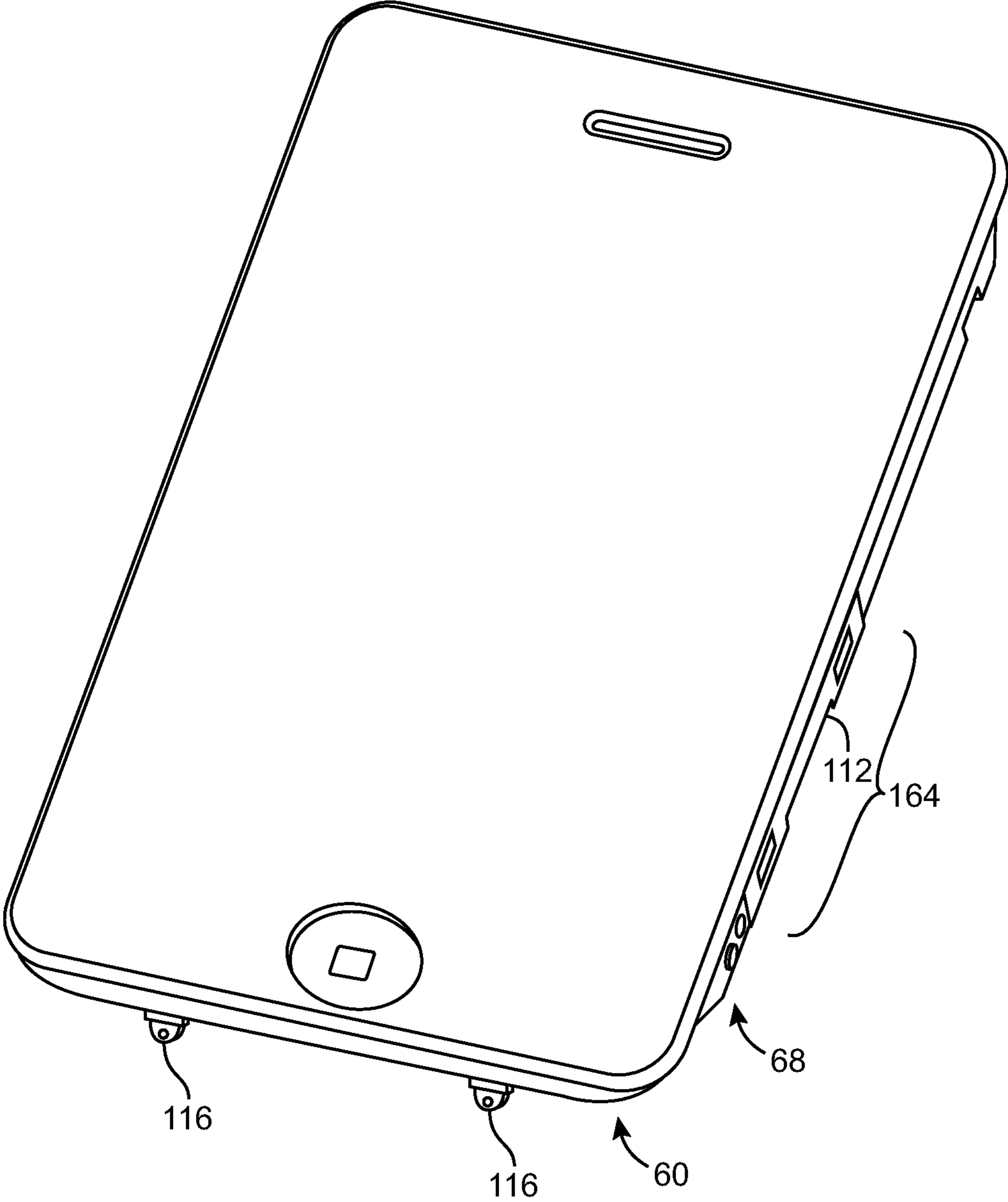


FIG. 11

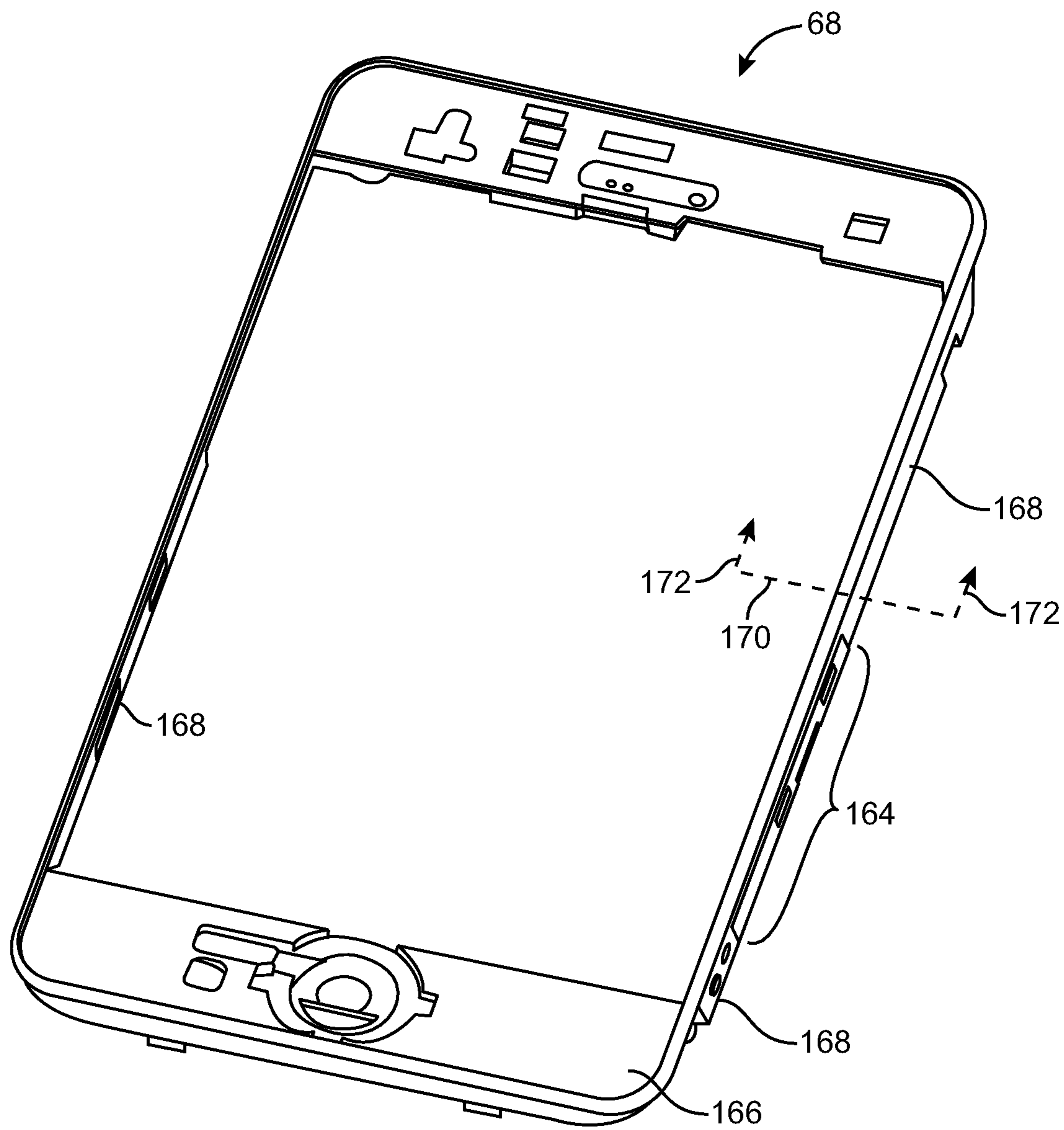


FIG. 12

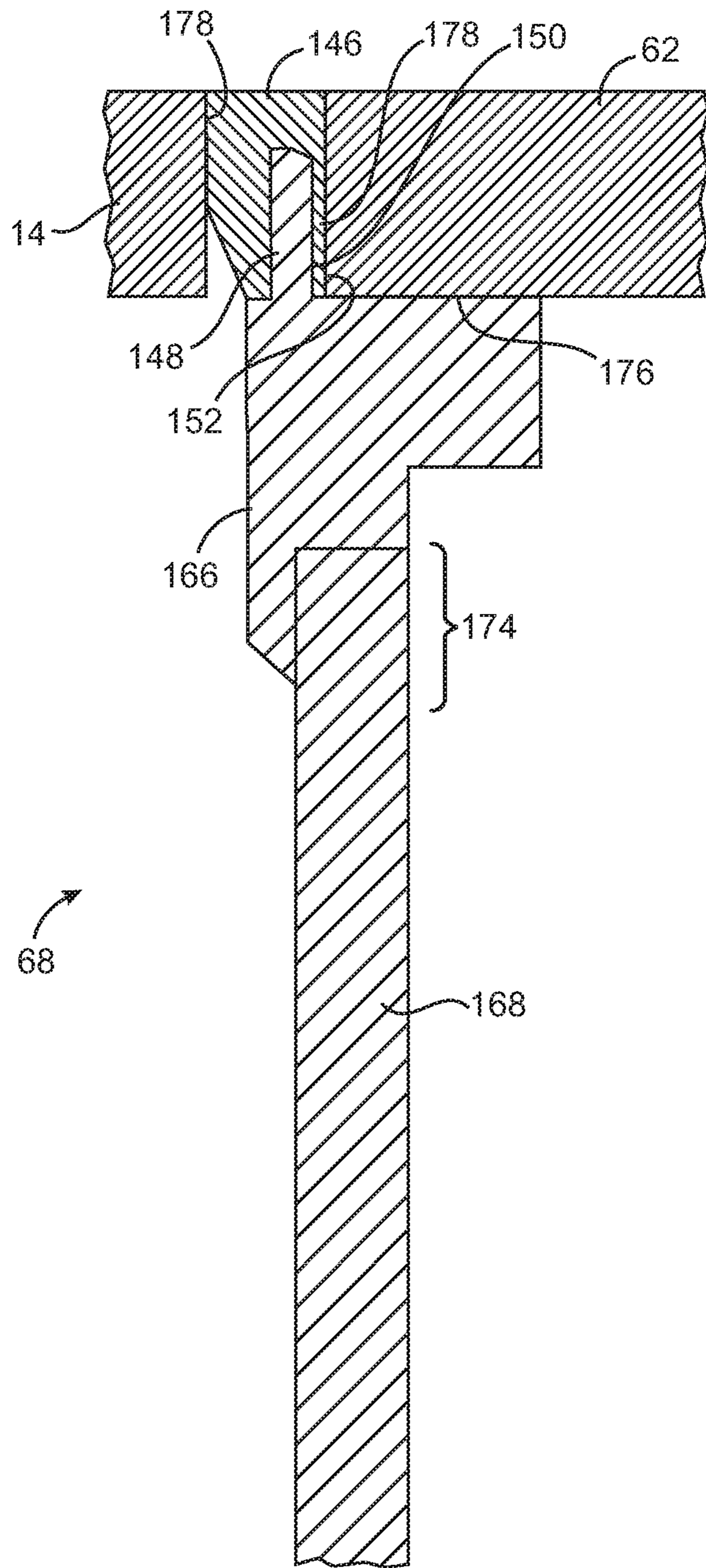


FIG. 13

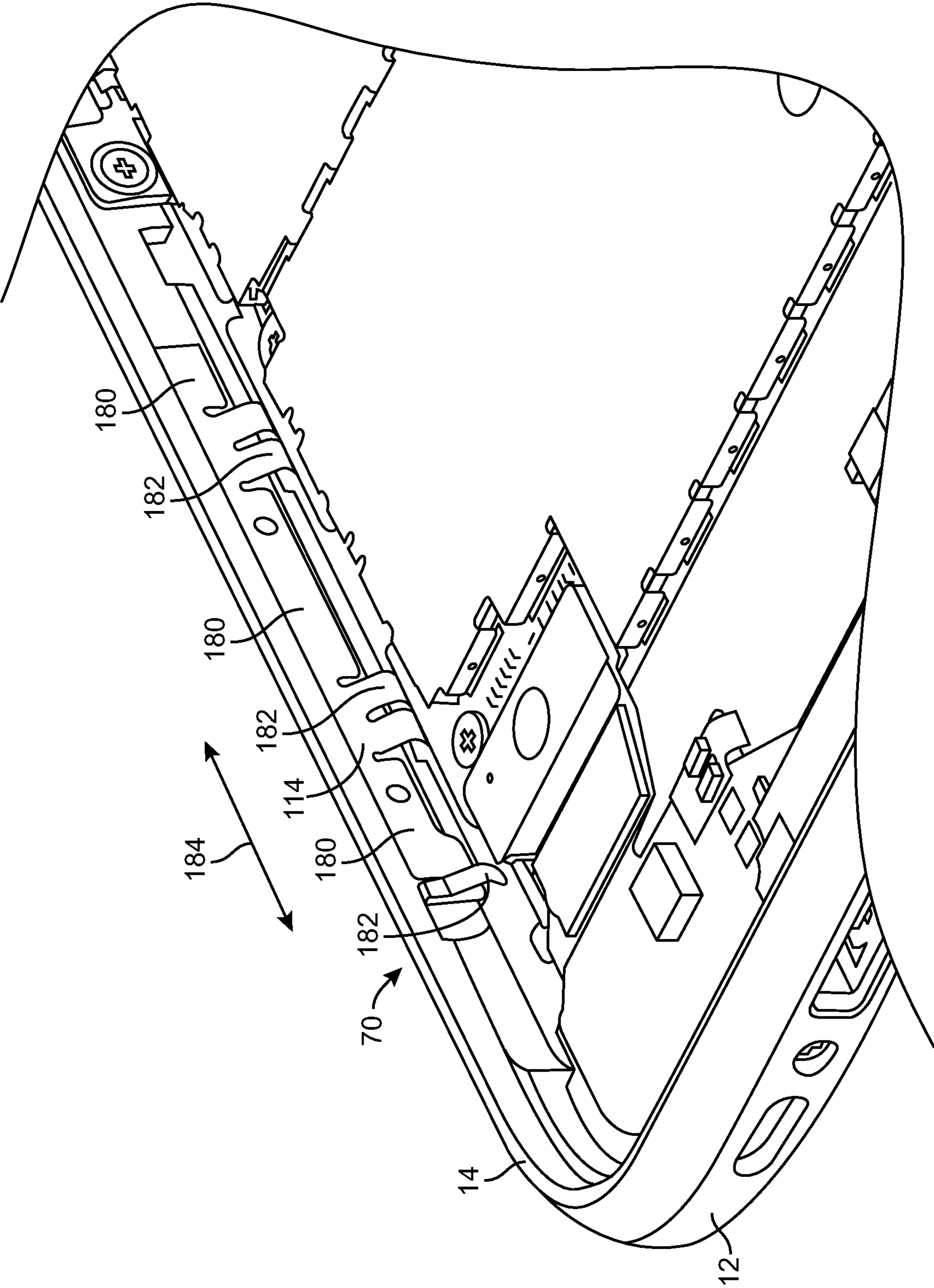


FIG. 14

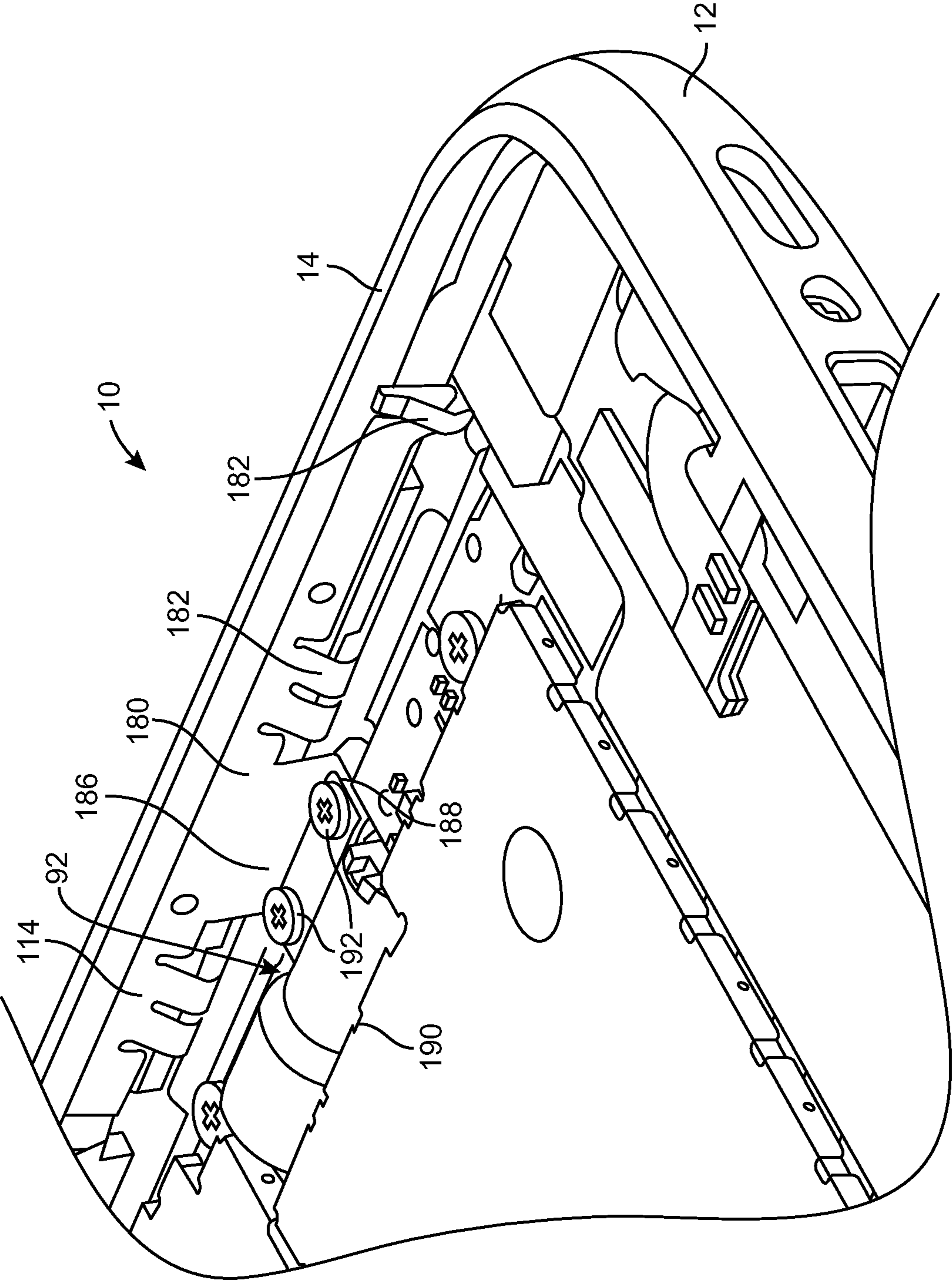


FIG. 15

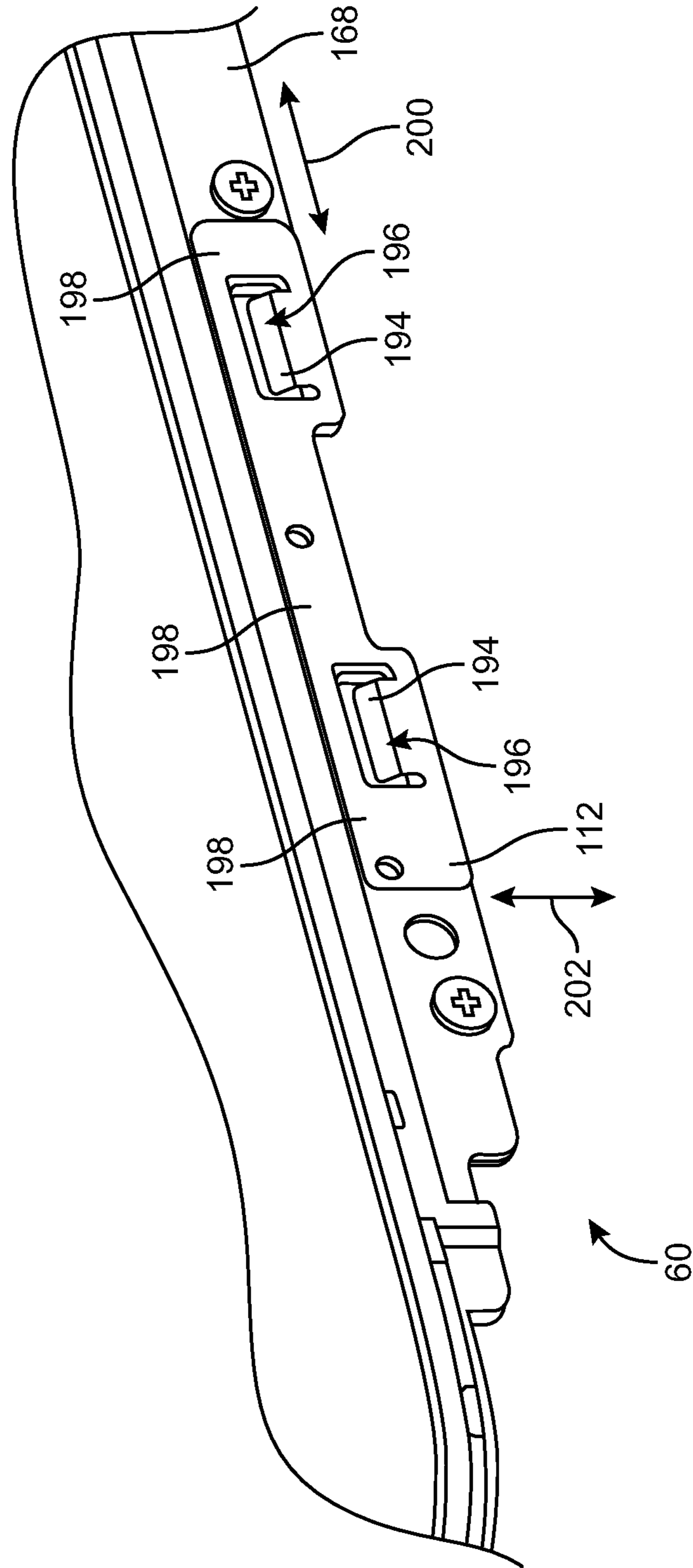


FIG. 16

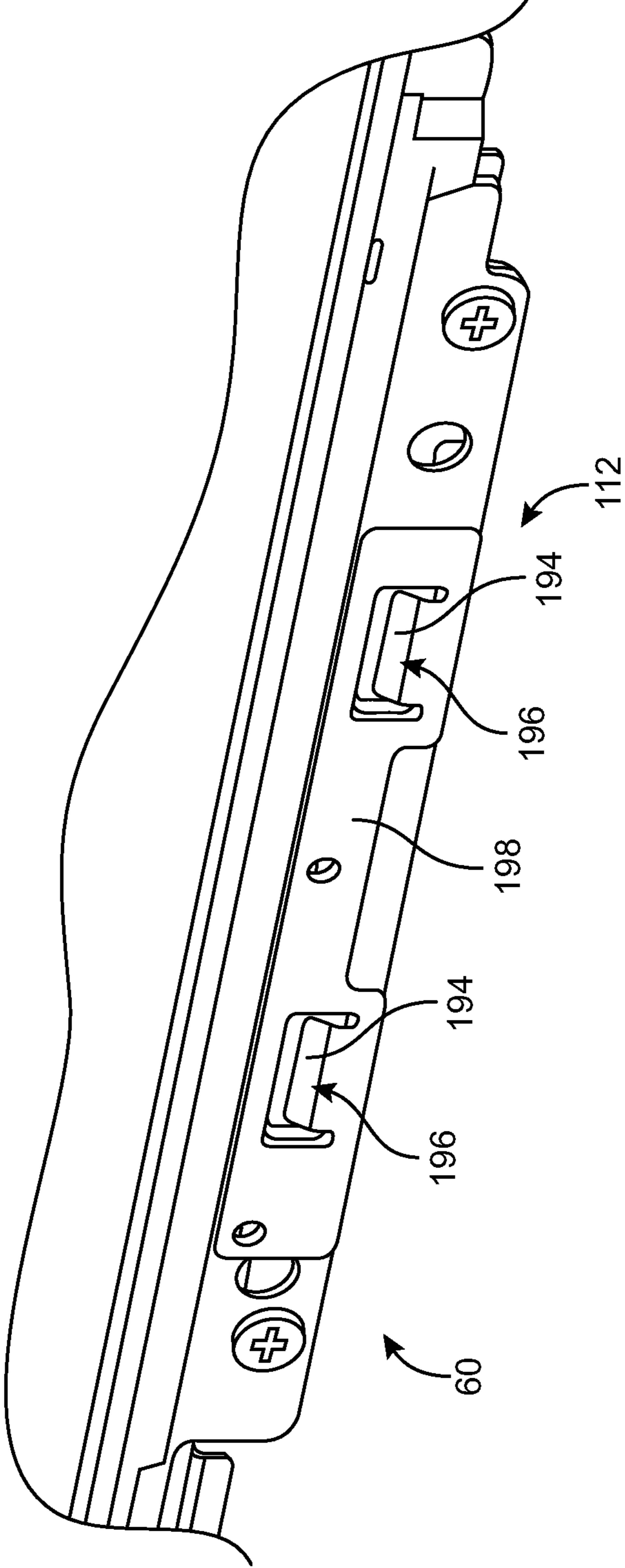


FIG. 17

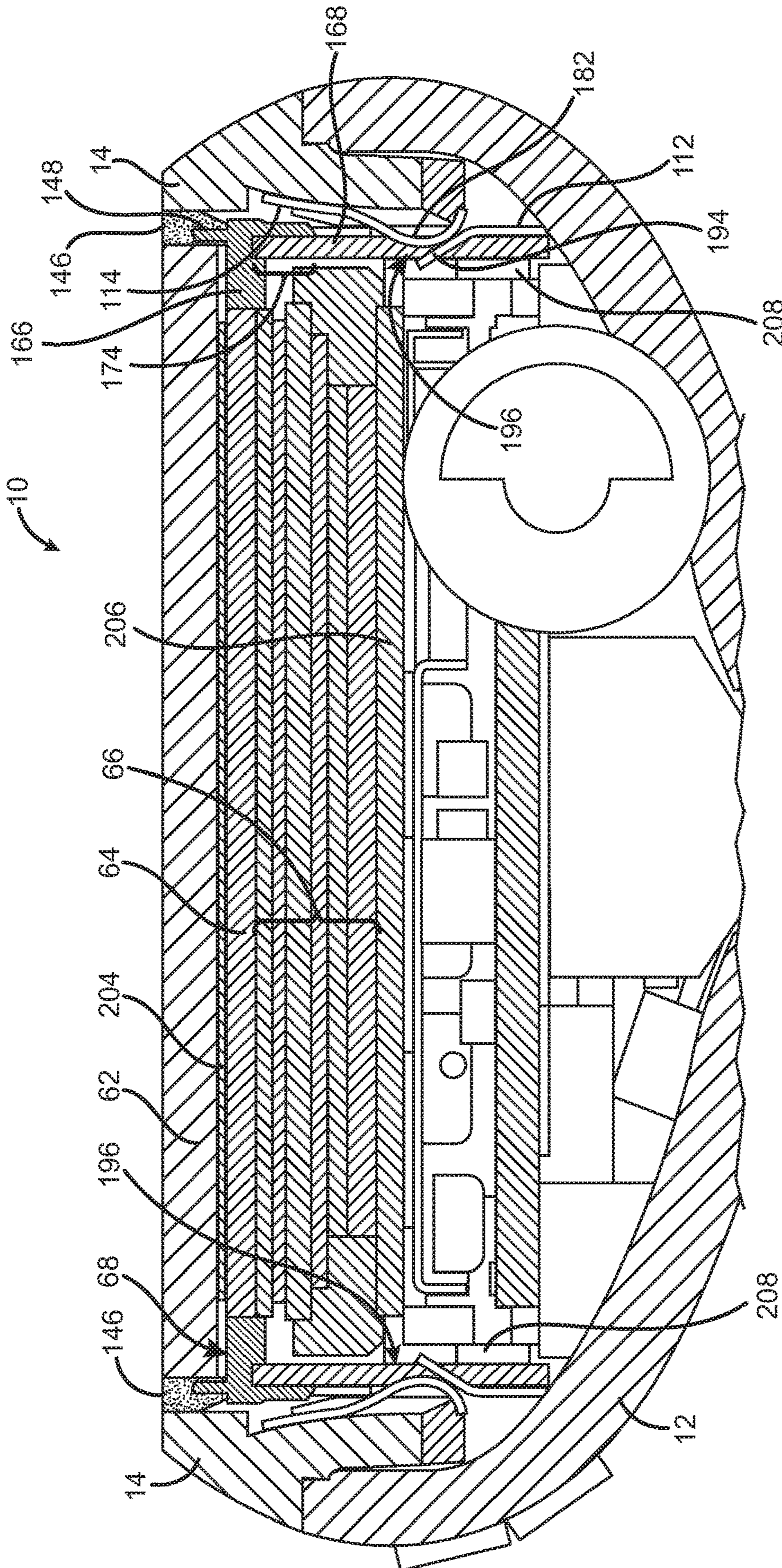


FIG. 18

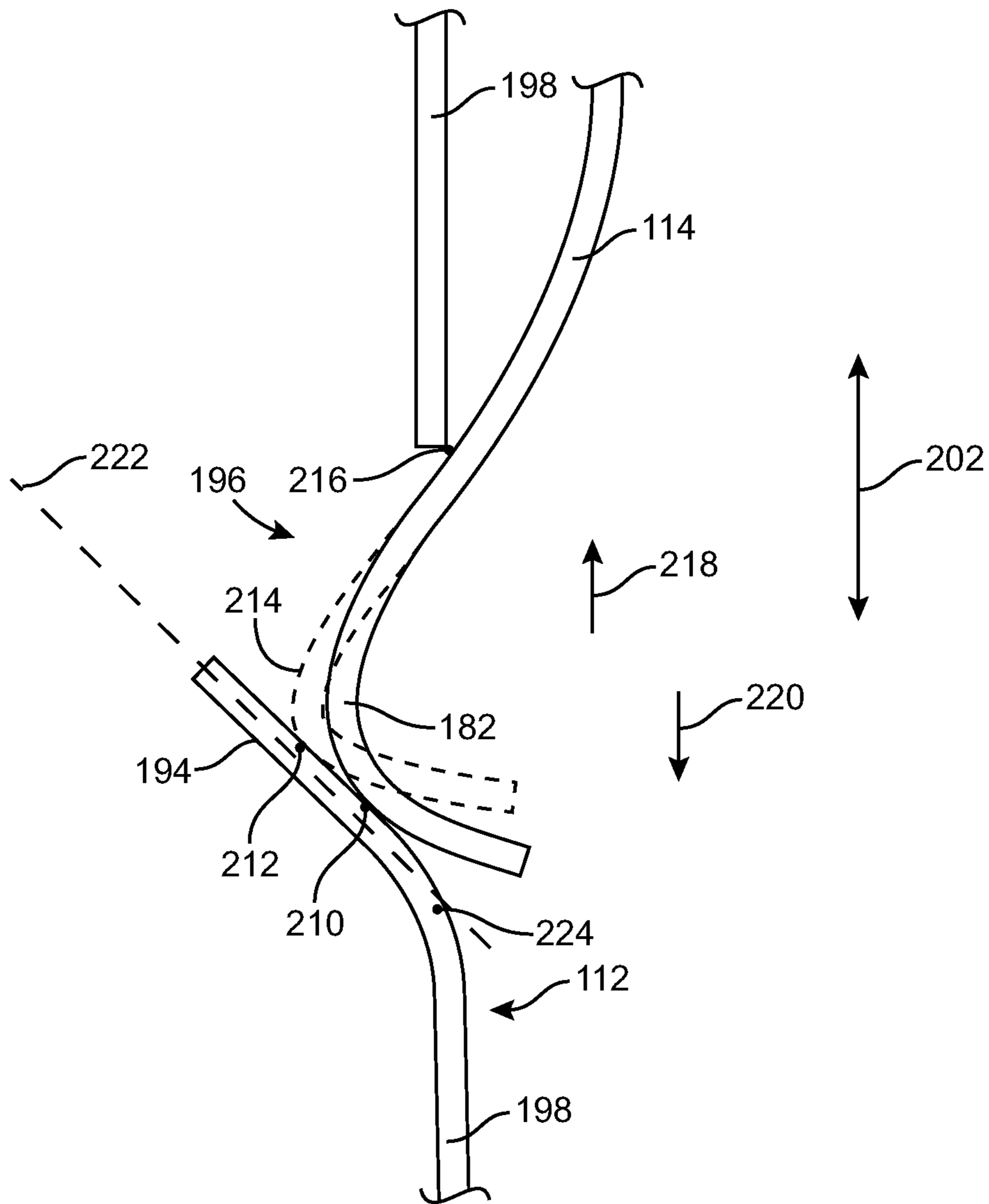


FIG. 19

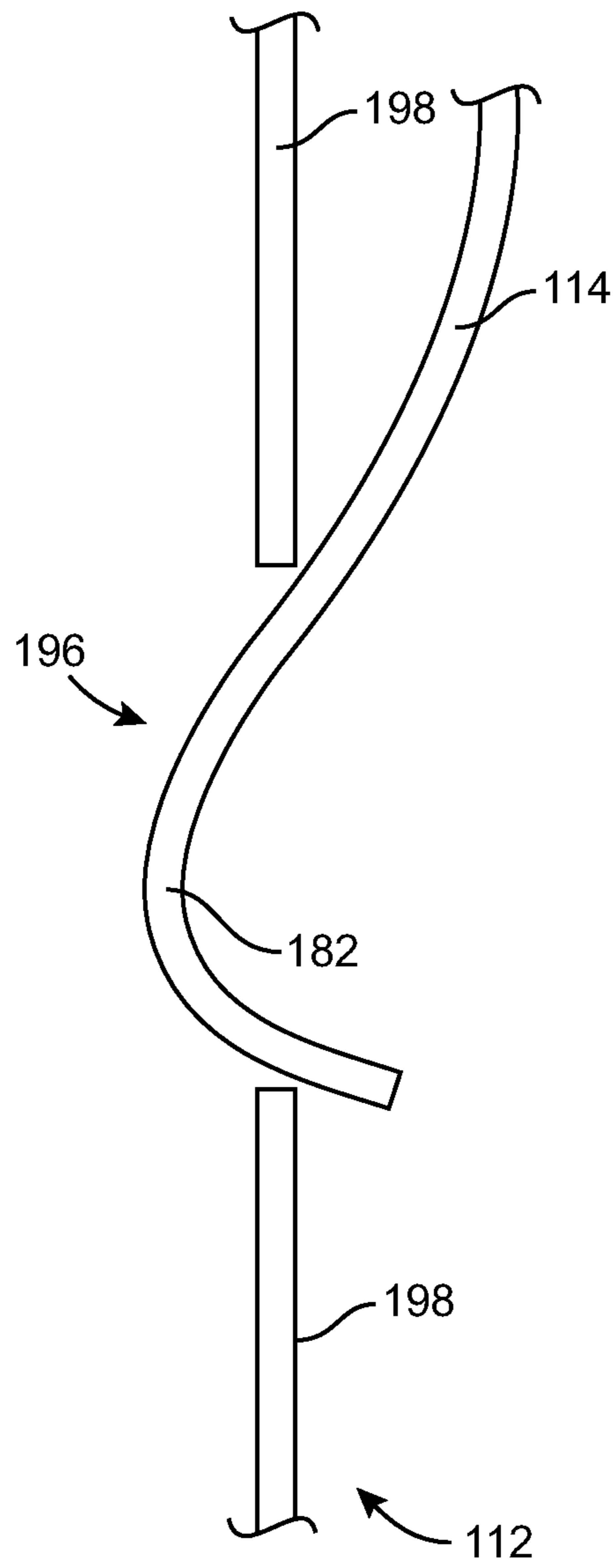


FIG. 20

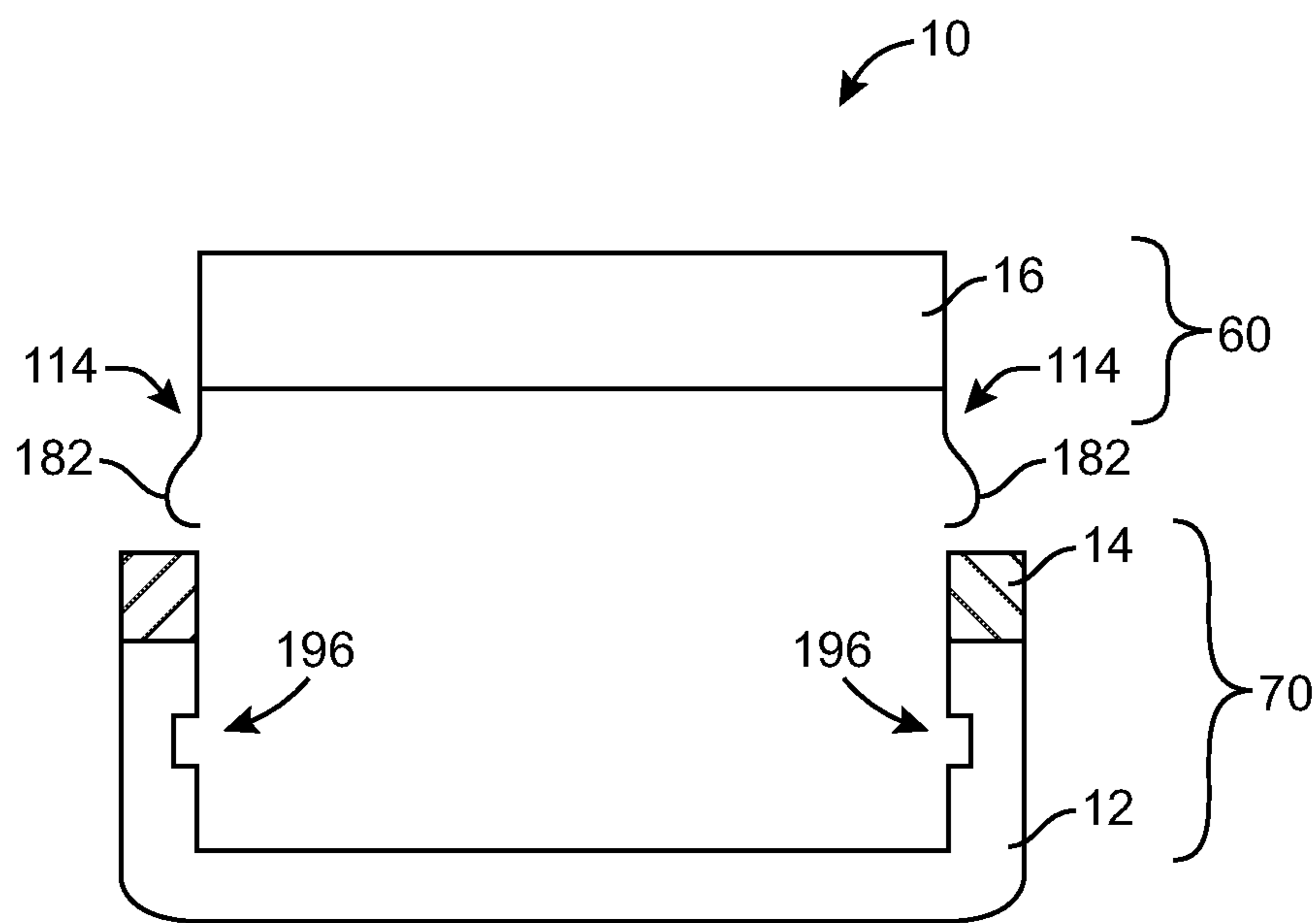


FIG. 21

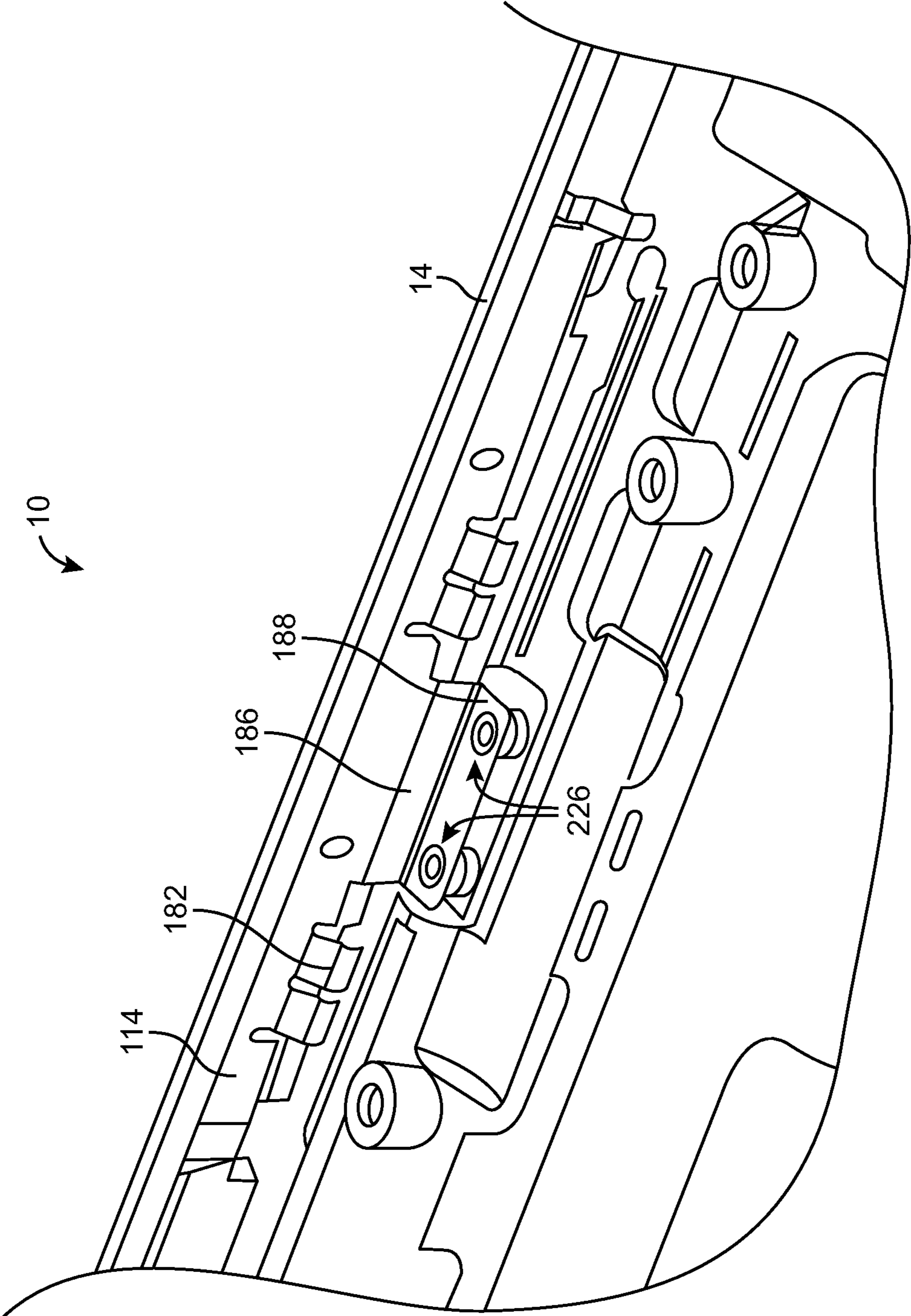


FIG. 22

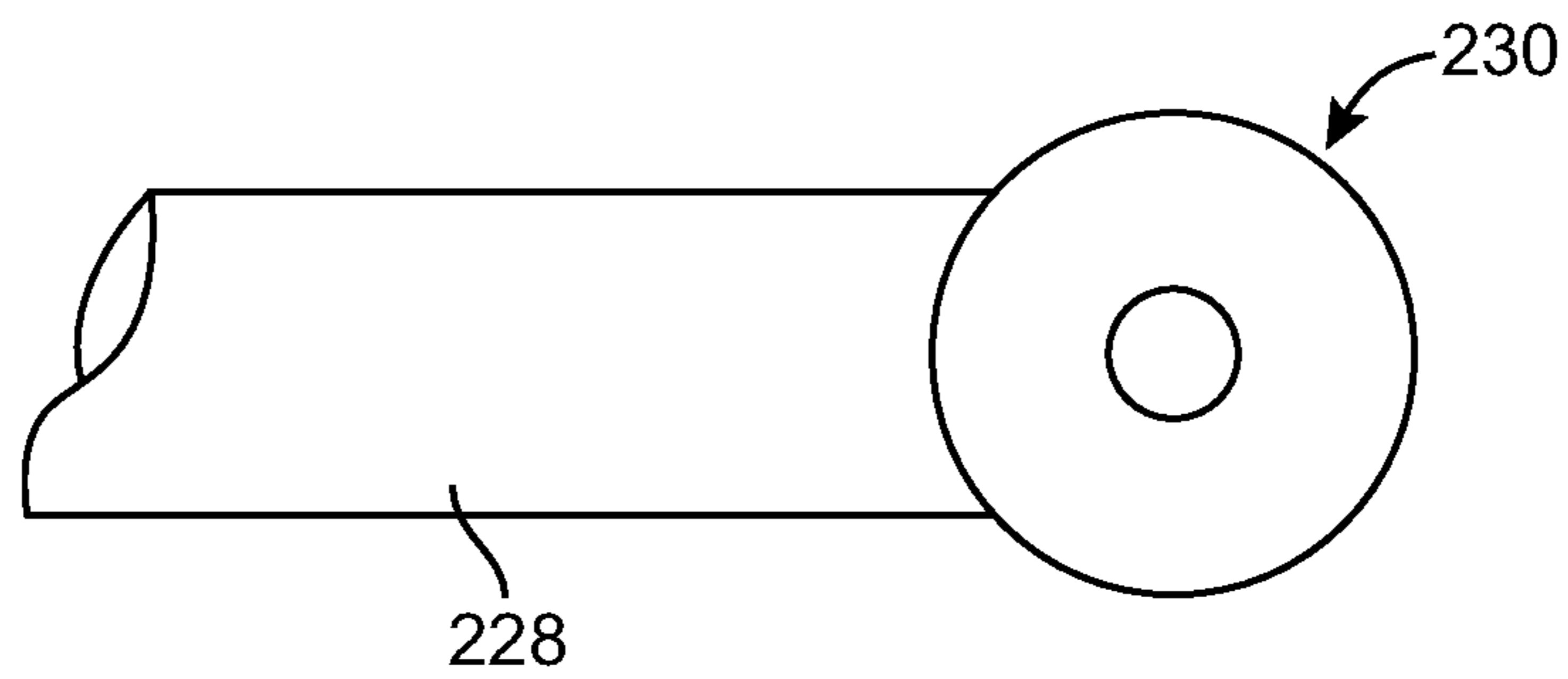


FIG. 23

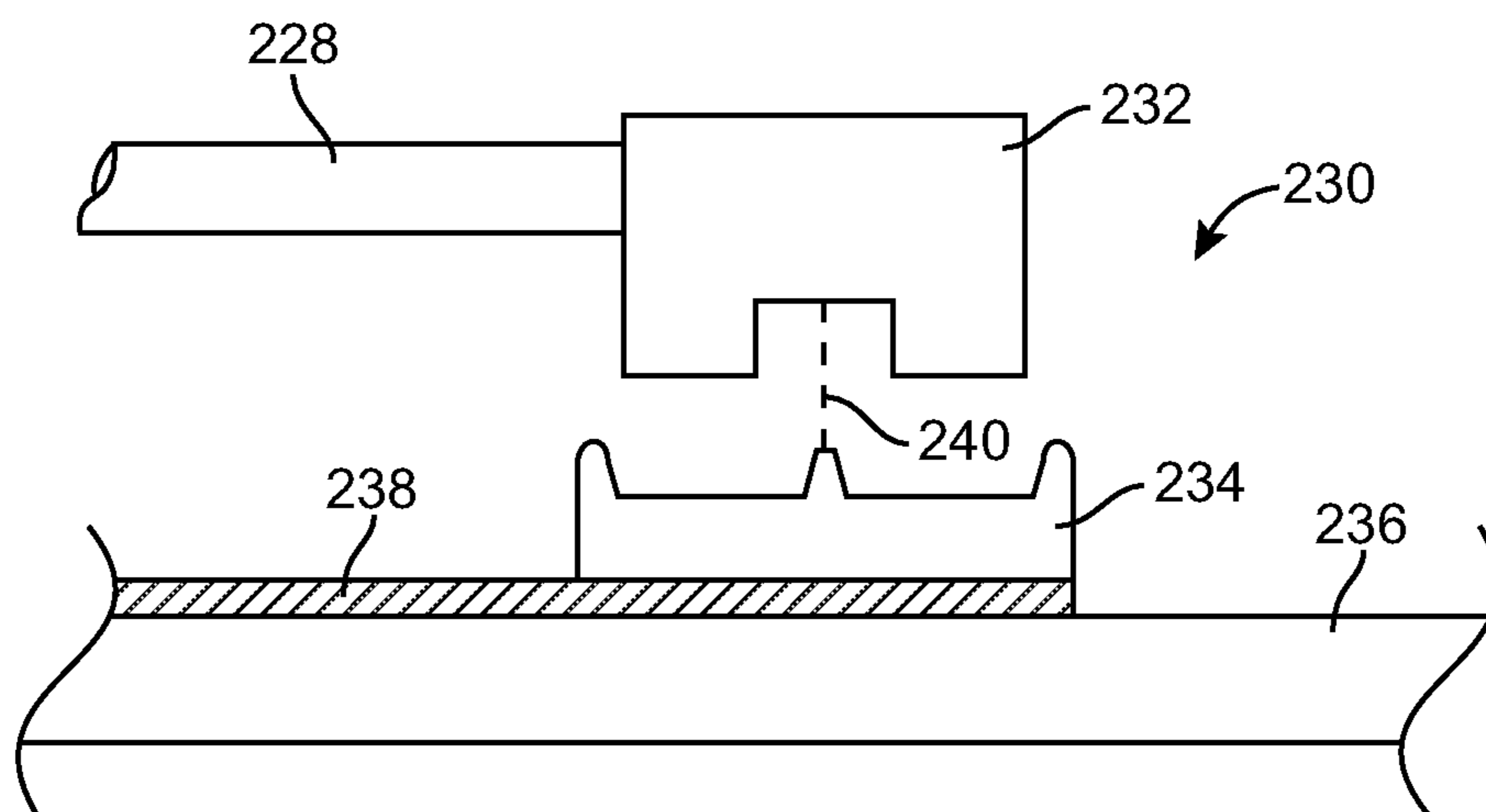


FIG. 24

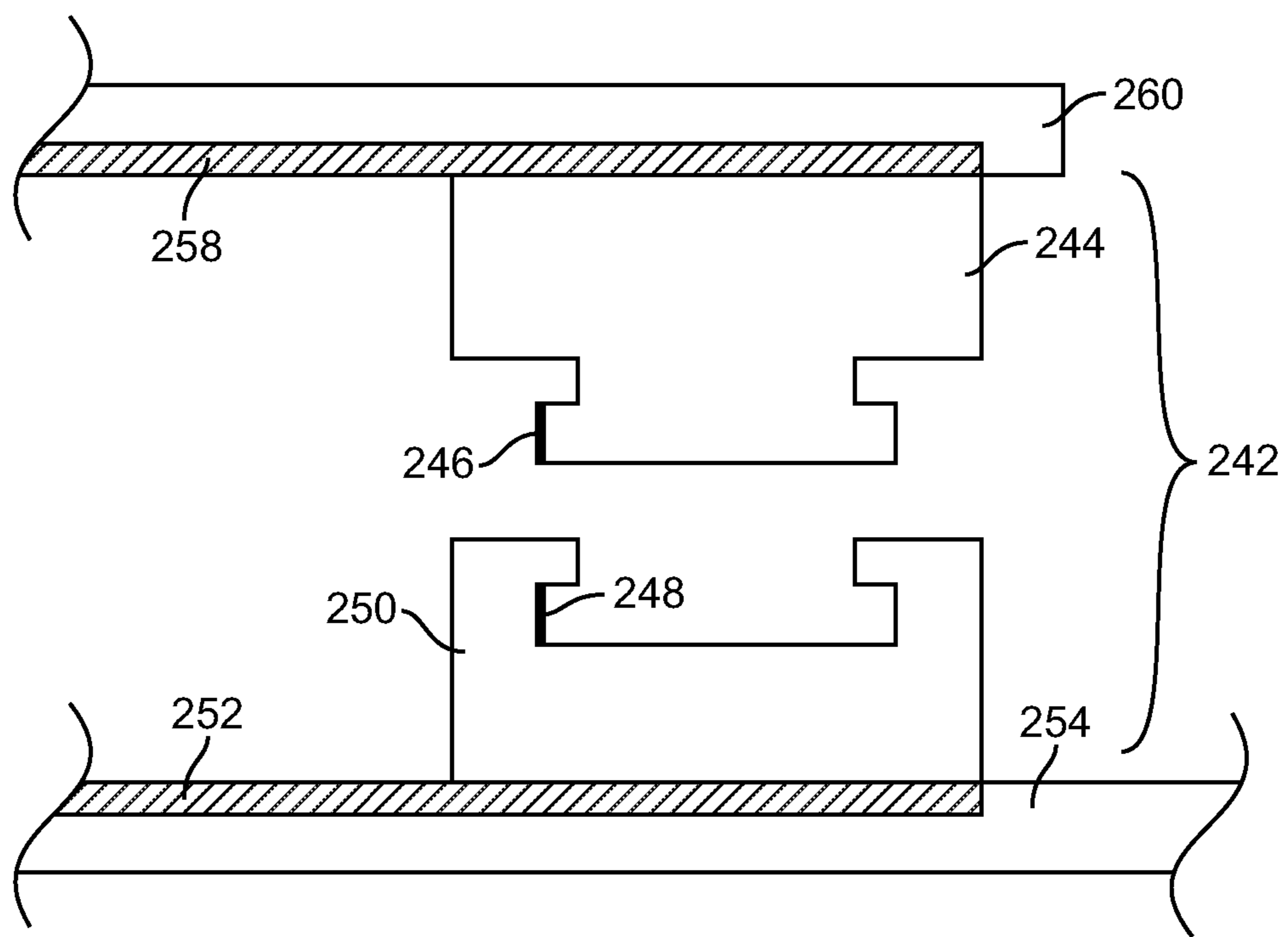


FIG. 25

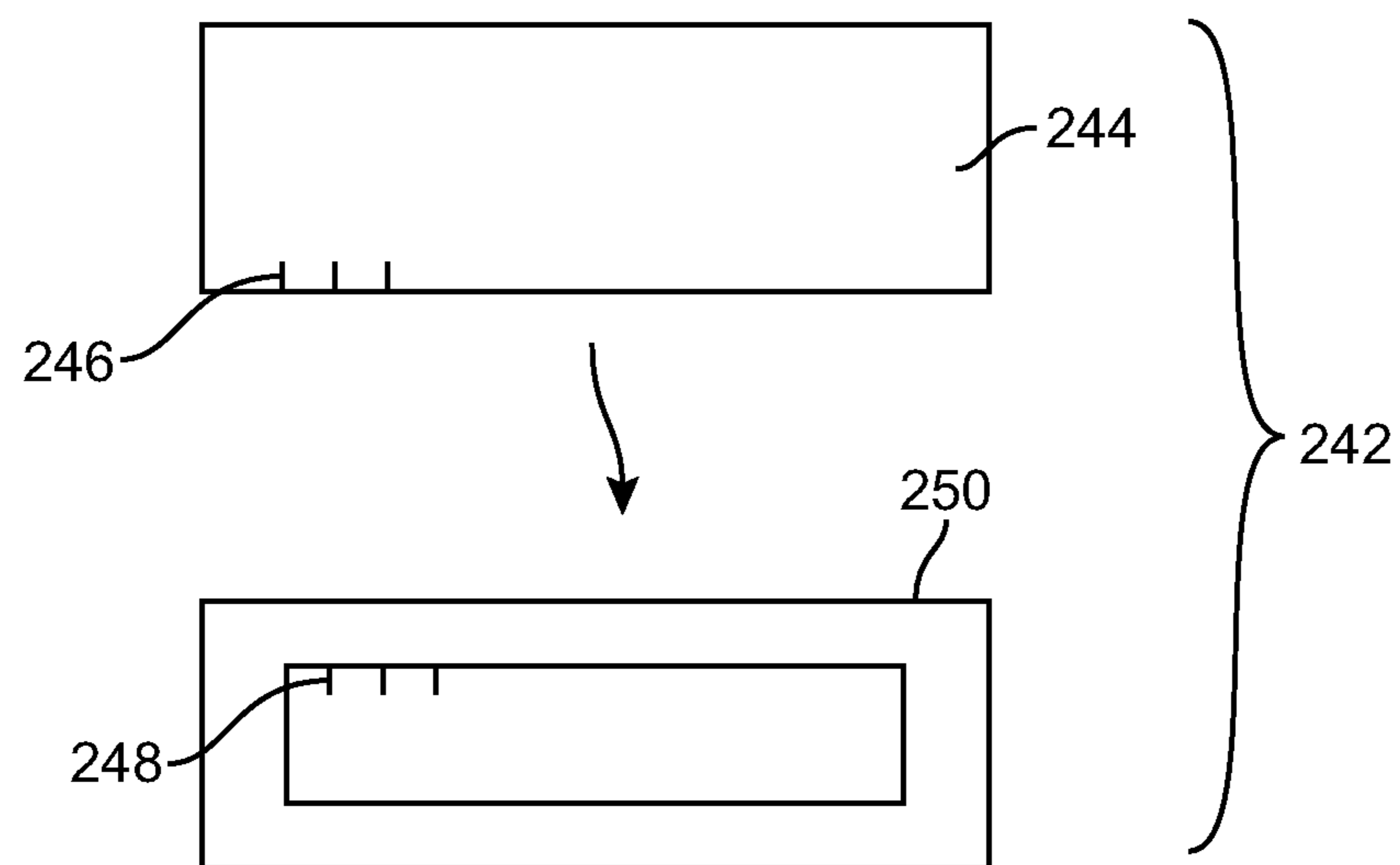


FIG. 26

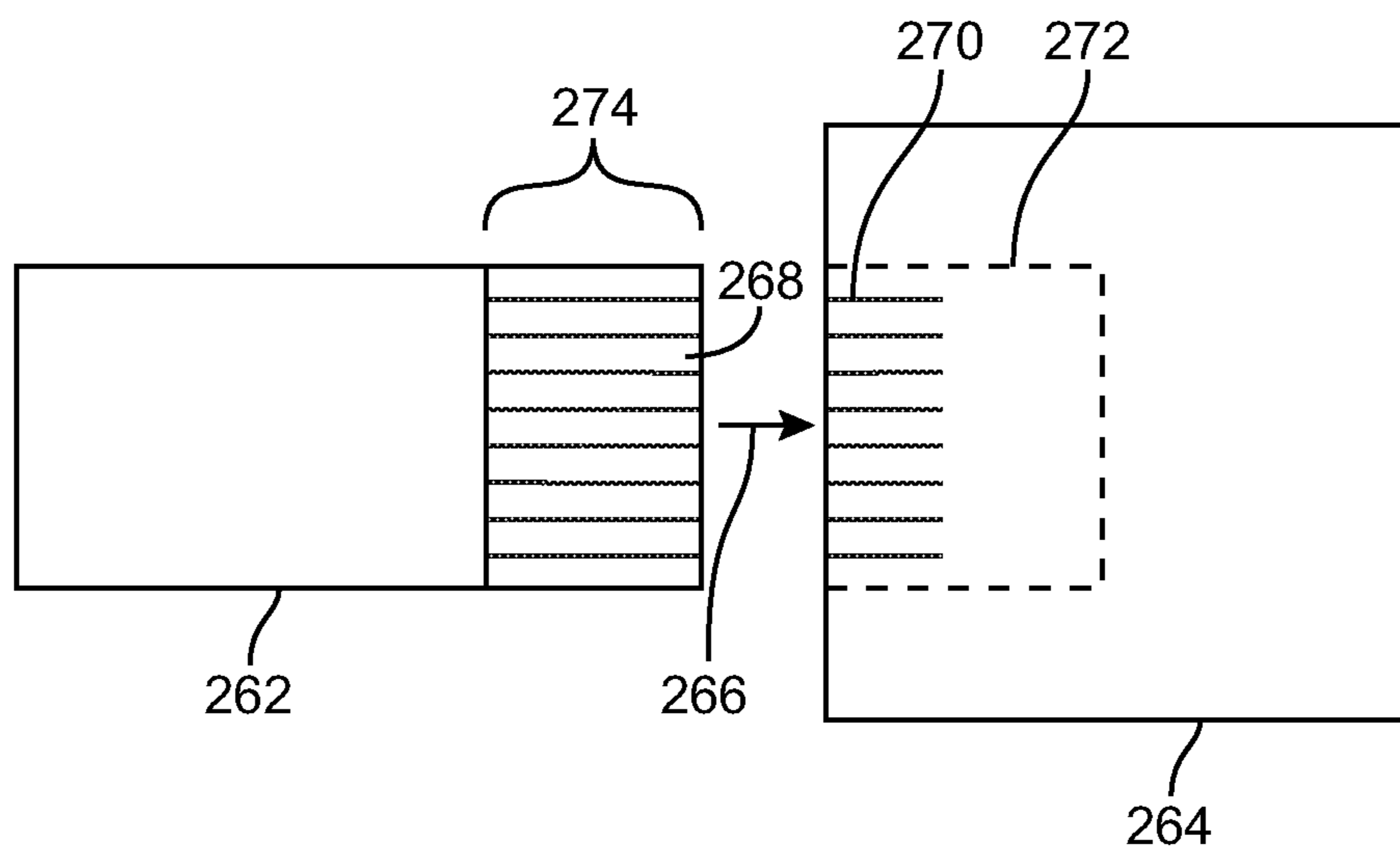


FIG. 27

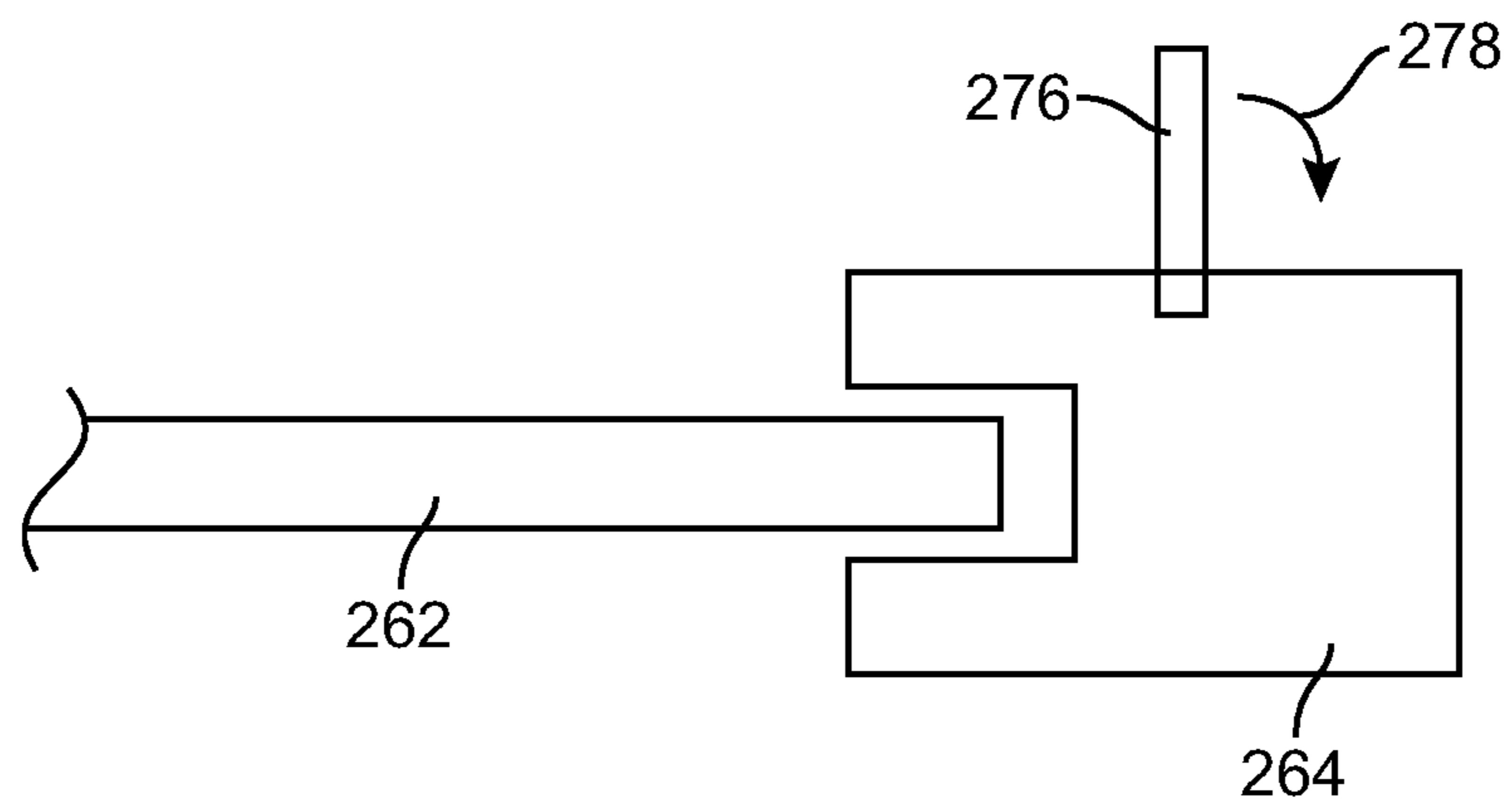


FIG. 28

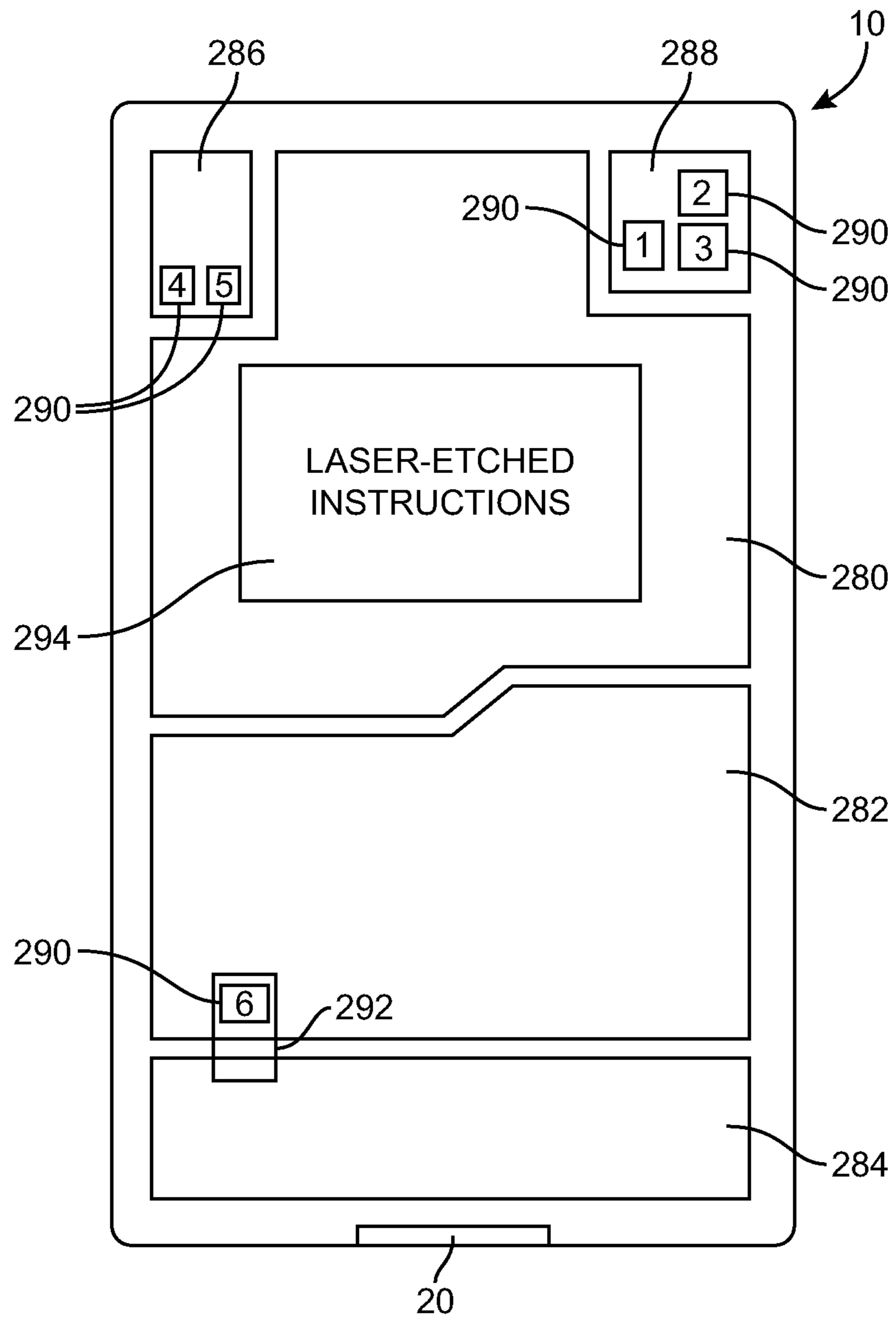


FIG. 29

PORTABLE ELECTRONIC DEVICE WITH TWO-PIECE HOUSING

This application is a continuation of patent application Ser. No. 15/098,742, filed Apr. 14, 2016, which is a continuation of patent application Ser. No. 13/525,725, filed Jun. 18, 2012, which is a continuation of patent application Ser. No. 13/084,490, filed Apr. 11, 2011, which is a division of patent application Ser. No. 12/119,986, filed May 13, 2008, now U.S. Pat. No. 7,933,123, which claims the benefit of provisional patent application No. 61/044,445, filed Apr. 11, 2008, all of which are hereby incorporated by reference herein in their entireties.

BACKGROUND

This invention relates generally to portable electronic devices, and more particularly, to portable electronic devices such as handheld electronic devices.

Handheld electronic devices and other portable electronic devices are becoming increasingly popular. Examples of handheld devices include handheld computers, cellular telephones, media players, and hybrid devices that include the functionality of multiple devices of this type. Popular portable electronic devices that are somewhat larger than traditional handheld electronic devices include laptop computers and tablet computers.

To satisfy consumer demand for small form factor devices such as handheld electronic devices, manufacturers are continually striving to reduce the size of components that are used in these devices while providing enhanced functionality. Significant enhancements may be difficult to implement, however, particularly in devices in which numerous components are used.

It would therefore be desirable to be able to provide improved handheld electronic devices.

SUMMARY

A portable electronic device such as a handheld electronic device is provided. The device may be formed from a tilt assembly and a housing assembly. During manufacturing, the tilt assembly may be inserted into the housing assembly.

The tilt assembly may include a frame. The frame may have a plastic frame member that is overmolded on top of metal frame struts. A planar mid-plate member may be connected to the frame to provide additional rigidity. Retention clips may be connected to one end of the frame. Threads in the retention clips may receive screws that may be used in securing the tilt assembly to the housing assembly.

Components such as a display unit, touch sensor, and cover glass may be mounted within the frame.

The housing assembly may include a plastic housing member, a bezel connected to the plastic housing member, and electrical components mounted within the plastic housing such as printed circuit boards, integrated circuits, etc.

Engagement members may be connected to the tilt assembly and housing assembly. During assembly, the engagement members may nondestructively engage one another to hold the tilt assembly within the housing assembly. In this configuration, the top surface of the cover glass may lie flush with the bezel on the housing assembly. The bezel may surround the cover glass. The frame may have a protrusion that surrounds the cover glass. The protrusion and other portions of the frame may form a shelf that supports the cover glass. To protect the cover glass from scratches due to contact with the bezel, an elastomeric gasket may be inter-

posed between the bezel and the cover glass. The gasket may be formed over the protrusion.

One or both of the engagement members may be flexible enough to allow the tilt assembly and the housing assembly to be taken apart without damaging the engagement members. This allows the portable electronic device to be disassembled for rework or repair operations.

The engagement members may include metal clips and metal springs. The metal clips may be welded to the frame struts. The metal springs may be welded to the bezel. The metal clips may have elongated planar members with cut-out portions. The cut-out portions may define holes and may be formed by bending planar portions of the elongated planar members so that they are angled inwardly. The bent planar portions of the clips form shelf-like members adjacent to the holes. The springs may have spring prongs that flex during assembly. Following assembly operations, the prongs protrude into the holes and hold the tilt assembly to the housing assembly. The prongs may have curved portions that bear against the planar shelf portions of the clips that are formed by the bent planar portions of the elongated members. The use of curves and the bent planar portions in the spring prongs and clip structures may help reduce harshness when inserting and removing the tilt assembly into the housing assembly and can improve mechanical tolerances.

Assembly instructions may be included within the housing. For example, laser etching techniques may be used to imprint instructions onto a metal can within the housing. Numbers or other assembly order indicators may be formed next to parts of the device. For example, a number may be placed next to each electrical connection that is to be formed. The electrical connections that are formed may include, zero-insertion-force connections, board-to-board connections, and coaxial cable connections. The instructions may refer to the assembly order indicators.

Further features of the invention, its nature and various advantages will be more apparent from the accompanying drawings and the following detailed description of the preferred embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of an illustrative portable electronic device in accordance with an embodiment of the present invention.

FIG. 2 is a schematic diagram of an illustrative portable electronic device in accordance with an embodiment of the present invention.

FIG. 3 is an exploded perspective view of an illustrative portable electronic device in accordance with an embodiment of the present invention.

FIG. 4 is a top view of an illustrative portable electronic device in accordance with an embodiment of the present invention.

FIG. 5 is an interior bottom view of an illustrative portable electronic device in accordance with an embodiment of the present invention.

FIG. 6 is a side view of an illustrative portable electronic device in accordance with an embodiment of the present invention.

FIG. 7 is a perspective view of a partially assembled portable electronic device in accordance with an embodiment of the present invention showing how an upper portion of the device may be inserted into a lower portion of the device.

FIG. 8 is a perspective view of a partially assembled portable electronic device of the type shown in FIG. 7 in

3

accordance with an embodiment of the present invention showing how the upper portion of the device may be tilted downwards into the lower portion of the device during assembly.

FIG. 9 is a perspective view of a fully assembled portable electronic device of the type shown in FIGS. 7 and 8 in accordance with an embodiment of the present invention.

FIG. 10 is a cross-sectional side view of an illustrative portable electronic device in accordance with an embodiment of the present invention.

FIG. 11 is a perspective view of an upper device assembly in accordance with an embodiment of the present invention.

FIG. 12 is a perspective view of a frame that may be used in forming an upper device assembly in accordance with an embodiment of the present invention.

FIG. 13 is a cross-sectional view of a portion of a frame showing how a gasket may be mounted to the frame to separate a bezel from a display in accordance with an embodiment of the present invention.

FIG. 14 is a perspective view of a portion of a lower device housing assembly in accordance with an embodiment of the present invention.

FIG. 15 is a perspective view of another portion of a lower device housing assembly in accordance with an embodiment of the present invention.

FIG. 16 is a perspective view of a portion of an upper device housing assembly in accordance with an embodiment of the present invention.

FIG. 17 is a perspective view of another portion of an upper device housing assembly in accordance with an embodiment of the present invention.

FIG. 18 is a cross-sectional end view of a portable electronic device in accordance with an embodiment of the present invention showing how springs may be used to hold an upper device assembly and lower device assembly together.

FIG. 19 is a cross-sectional view of an illustrative spring and matching clip that may be used to attach upper and lower housing portions together in accordance with an embodiment of the present invention.

FIG. 20 is a cross-sectional view of another illustrative spring and matching clip that may be used to attach upper and lower housing portions together in accordance with an embodiment of the present invention.

FIG. 21 is a cross-sectional view of an illustrative spring and matching clip arrangement for securing housing portions together in a portable electronic device arrangement in which the springs are attached to an upper housing assembly in accordance with an embodiment of the present invention.

FIG. 22 is a perspective view of an interior portion of a portable device housing showing how springs may be used to form a mounting region for an electronic component in accordance with an embodiment of the present invention.

FIG. 23 is a top view of an illustrative coaxial cable connector in accordance with an embodiment of the present invention.

FIG. 24 is a side view of an illustrative coaxial cable connector in accordance with an embodiment of the present invention.

FIG. 25 is a side view of an illustrative board-to-board connector in accordance with an embodiment of the present invention.

FIG. 26 is a top view of an illustrative board-to-board connector in accordance with an embodiment of the present invention.

4

FIG. 27 is a top view of an illustrative zero-insertion-force connector for forming a connection with a flex circuit communications path in accordance with an embodiment of the present invention.

FIG. 28 is a side view of an illustrative zero-insertion-force connector for forming a connection with a flex circuit communications path in accordance with an embodiment of the present invention.

FIG. 29 is a top view of an interior portion of illustrative portable electronic device having numbered connector regions and laser-etched assembly instructions in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION

The present invention relates generally to electronic devices, and more particularly, to portable electronic devices such as handheld electronic devices.

The electronic devices may be portable electronic devices such as laptop computers or small portable computers of the type that are sometimes referred to as ultraportables. Portable electronic devices may also be somewhat smaller devices. Examples of smaller portable electronic devices include wrist-watch devices, pendant devices, headphone and earpiece devices, and other wearable and miniature devices. With one suitable arrangement, the portable electronic devices may be wireless electronic devices.

The wireless electronic devices may be, for example, handheld wireless devices such as cellular telephones, media players with wireless communications capabilities, handheld computers (also sometimes called personal digital assistants), remote controllers, global positioning system (GPS) devices, and handheld gaming devices. The wireless electronic devices may also be hybrid devices that combine the functionality of multiple conventional devices. Examples of hybrid portable electronic devices include a cellular telephone that includes media player functionality, a gaming device that includes a wireless communications capability, a cellular telephone that includes game and email functions, and a portable device that receives email, supports mobile telephone calls, has music player functionality and supports web browsing. These are merely illustrative examples.

An illustrative portable electronic device in accordance with an embodiment of the present invention is shown in FIG. 1. Device 10 of FIG. 1 may be, for example, a handheld electronic device that supports 2G and/or 3G cellular telephone and data functions, global positioning system capabilities, and local wireless communications capabilities (e.g., IEEE 802.11 and Bluetooth®) and that supports handheld computing device functions such as internet browsing, email and calendar functions, games, music player functionality, etc.

Device 10 may have housing 12. Antennas for handling wireless communications may be housed within housing 12 (as an example).

Housing 12, which is sometimes referred to as a case, may be formed of any suitable materials including, plastic, glass, ceramics, metal, or other suitable materials, or a combination of these materials. In some situations, housing 12 or portions of housing 12 may be formed from a dielectric or other low-conductivity material, so that the operation of conductive antenna elements that are located in proximity to housing 12 is not disrupted. Housing 12 or portions of housing 12 may also be formed from conductive materials such as metal. An advantage of forming housing 12 from a dielectric material such as plastic is that this may help to

5

reduce the overall weight of device **10** and may avoid potential interference with wireless operations.

In scenarios in which housing **12** is formed from metal elements, one or more of the metal elements may be used as part of the antennas in device **10**. For example, metal portions of housing **12** may be shorted to an internal ground plane in device **10** to create a larger ground plane element for that device **10**.

Housing **12** may have a bezel **14**. The bezel **14** may be formed from a conductive material or other suitable material. Bezel **14** may serve to hold a display or other device with a planar surface in place on device **10** and/or may serve to form an esthetically pleasing trim around the edge of device **10**. As shown in FIG. **1**, for example, bezel **14** may be used to surround the top of display **16**. Bezel **14** and/or other metal elements associated with device **10** may be used as part of the antennas in device **10**. For example, bezel **14** may be shorted to printed circuit board conductors or other internal ground plane structures in device **10** to create a larger ground plane element for device **10**.

Display **16** may be a liquid crystal display (LCD), an organic light emitting diode (OLED) display, or any other suitable display. The outermost surface of display **16** may be formed from one or more plastic or glass layers. If desired, touch screen functionality may be integrated into display **16** or may be provided using a separate touch pad device. An advantage of integrating a touch screen into display **16** to make display **16** touch sensitive is that this type of arrangement can save space and reduce visual clutter.

Display screen **16** (e.g., a touch screen) is merely one example of an input-output device that may be used with electronic device **10**. If desired, electronic device **10** may have other input-output devices. For example, electronic device **10** may have user input control devices such as button **19**, and input-output components such as port **20** and one or more input-output jacks (e.g., for audio and/or video). Button **19** may be, for example, a menu button. Port **20** may contain a 30-pin data connector (as an example). Openings **22** and **24** may, if desired, form speaker and microphone ports. Speaker port **22** may be used when operating device **10** in speakerphone mode. Opening **23** may also form a speaker port. For example, speaker port **23** may serve as a telephone receiver that is placed adjacent to a user's ear during operation. In the example of FIG. **1**, display screen **16** is shown as being mounted on the front face of handheld electronic device **10**, but display screen **16** may, if desired, be mounted on the rear face of handheld electronic device **10**, on a side of device **10**, on a flip-up portion of device **10** that is attached to a main body portion of device **10** by a hinge (for example), or using any other suitable mounting arrangement.

A user of electronic device **10** may supply input commands using user input interface devices such as button **19** and touch screen **16**. Suitable user input interface devices for electronic device **10** include buttons (e.g., alphanumeric keys, power on-off, power-on, power-off, and other specialized buttons, etc.), a touch pad, pointing stick, or other cursor control device, a microphone for supplying voice commands, or any other suitable interface for controlling device **10**. Although shown schematically as being formed on the top face of electronic device **10** in the example of FIG. **1**, buttons such as button **19** and other user input interface devices may generally be formed on any suitable portion of electronic device **10**. For example, a button such as button **19** or other user interface control may be formed on the side of electronic device **10**. Buttons and other user interface controls can also be located on the top face, rear

6

face, or other portion of device **10**. If desired, device **10** can be controlled remotely (e.g., using an infrared remote control, a radio-frequency remote control such as a Bluetooth® remote control, etc.).

Electronic device **10** may have ports such as port **20**. Port **20**, which may sometimes be referred to as a dock connector, 30-pin data port connector, input-output port, or bus connector, may be used as an input-output port (e.g., when connecting device **10** to a mating dock connected to a computer or other electronic device). Port **20** may contain pins for receiving data and power signals. Device **10** may also have audio and video jacks that allow device **10** to interface with external components. Typical ports include power jacks to recharge a battery within device **10** or to operate device **10** from a direct current (DC) power supply, data ports to exchange data with external components such as a personal computer or peripheral, audio-visual jacks to drive headphones, a monitor, or other external audio-video equipment, a subscriber identity module (SIM) card port to authorize cellular telephone service, a memory card slot, etc. The functions of some or all of these devices and the internal circuitry of electronic device **10** can be controlled using input interface devices such as touch screen display **16**.

Components such as display **16** and other user input interface devices may cover most of the available surface area on the front face of device **10** (as shown in the example of FIG. **1**) or may occupy only a small portion of the front face of device **10**. Because electronic components such as display **16** often contain large amounts of metal (e.g., as radio-frequency shielding), the location of these components relative to the antenna elements in device **10** should generally be taken into consideration. Suitably chosen locations for the antenna elements and electronic components of the device will allow the antennas of electronic device **10** to function properly without being disrupted by the electronic components.

Examples of locations in which antenna structures may be located in device **10** include region **18** and region **21**. These are merely illustrative examples. Any suitable portion of device **10** may be used to house antenna structures for device **10** if desired.

A schematic diagram of an embodiment of an illustrative portable electronic device such as a handheld electronic device is shown in FIG. **2**. Portable device **10** may be a mobile telephone, a mobile telephone with media player capabilities, a handheld computer, a remote control, a game player, a global positioning system (GPS) device, a laptop computer, a tablet computer, an ultraportable computer, a hybrid device that includes the functionality of some or all of these devices, or any other suitable portable electronic device.

As shown in FIG. **2**, device **10** may include storage **34**. Storage **34** may include one or more different types of storage such as hard disk drive storage, nonvolatile memory (e.g., flash memory or other electrically-programmable-read-only memory), volatile memory (e.g., battery-based static or dynamic random-access-memory), etc.

Processing circuitry **36** may be used to control the operation of device **10**. Processing circuitry **36** may be based on a processor such as a microprocessor and other suitable integrated circuits. With one suitable arrangement, processing circuitry **36** and storage **34** are used to run software on device **10**, such as internet browsing applications, voice-over-internet-protocol (VOIP) telephone call applications, email applications, media playback applications, operating system functions, etc. Processing circuitry **36** and storage **34** may be used in implementing suitable communications

protocols. Communications protocols that may be implemented using processing circuitry **36** and storage **34** include internet protocols, wireless local area network protocols (e.g., IEEE 802.11 protocols—sometimes referred to as Wi-Fi®), protocols for other short-range wireless communications links such as the Bluetooth® protocol, protocols for handling 3G communications services (e.g., using wide band code division multiple access techniques), 2G cellular telephone communications protocols, etc.

To minimize power consumption, processing circuitry **36** may include power management circuitry to implement power management functions. During operation, the power management circuitry or other processing circuitry **36** may be used to adjust power supply voltages that are provided to portions of the circuitry on device **10**. For example, higher direct-current (DC) power supply voltages may be supplied to active circuits and lower DC power supply voltages may be supplied to circuits that are less active or that are inactive.

Input-output devices **38** may be used to allow data to be supplied to device **10** and to allow data to be provided from device **10** to external devices. Display screen **16**, button **19**, microphone port **24**, speaker port **22**, and dock connector port **20** are examples of input-output devices **38**.

Input-output devices **38** can include user input-output devices **40** such as buttons, touch screens, joysticks, click wheels, scrolling wheels, touch pads, key pads, keyboards, microphones, cameras, etc. A user can control the operation of device **10** by supplying commands through user input devices **40**. Display and audio devices **42** may include liquid-crystal display (LCD) screens or other screens, light-emitting diodes (LEDs), and other components that present visual information and status data. Display and audio devices **42** may also include audio equipment such as speakers and other devices for creating sound. Display and audio devices **42** may contain audio-video interface equipment such as jacks and other connectors for external headphones and monitors.

Wireless communications devices **44** may include communications circuitry such as radio-frequency (RF) transceiver circuitry formed from one or more integrated circuits, power amplifier circuitry, passive RF components, antennas, and other circuitry for handling RF wireless signals. Wireless signals can also be sent using light (e.g., using infrared communications).

Device **10** can communicate with external devices such as accessories **46**, computing equipment **48**, and wireless network **49** as shown by paths **50** and **51**. Paths **50** may include wired and wireless paths. Path **51** may be a wireless path. Accessories **46** may include headphones (e.g., a wireless cellular headset or audio headphones) and audio-video equipment (e.g., wireless speakers, a game controller, or other equipment that receives and plays audio and video content), a peripheral such as a wireless printer or camera, etc.

Computing equipment **48** may be any suitable computer. With one suitable arrangement, computing equipment **48** is a computer that has an associated wireless access point (router) or an internal or external wireless card that establishes a wireless connection with device **10**. The computer may be a server (e.g., an internet server), a local area network computer with or without internet access, a user's own personal computer, a peer device (e.g., another portable electronic device **10**), or any other suitable computing equipment.

Wireless network **49** may include any suitable network equipment, such as cellular telephone base stations, cellular towers, wireless data networks, computers associated with

wireless networks, etc. For example, wireless network **49** may include network management equipment that monitors the wireless signal strength of the wireless handsets (cellular telephones, handheld computing devices, etc.) that are in communication with network **49**.

The antenna structures and wireless communications devices of device **10** may support communications over any suitable wireless communications bands. For example, wireless communications devices **44** may be used to cover communications frequency bands such as cellular telephone voice and data bands at 850 MHz, 900 MHz, 1800 MHz, 1900 MHz, and 2100 MHz (as examples). Devices **44** may also be used to handle the Wi-Fi® (IEEE 802.11) bands at 2.4 GHz and 5.0 GHz (also sometimes referred to as wireless local area network or WLAN bands), the Bluetooth® band at 2.4 GHz, and the global positioning system (GPS) band at 1575 MHz.

Device **10** can cover these communications bands and/or other suitable communications bands with proper configuration of the antenna structures in wireless communications circuitry **44**. Any suitable antenna structures may be used in device **10**. For example, device **10** may have one antenna or may have multiple antennas. The antennas in device **10** may each be used to cover a single communications band or each antenna may cover multiple communications bands. If desired, one or more antennas may cover a single band while one or more additional antennas are each used to cover multiple bands. As an example, a pentaband cellular telephone antenna may be provided at one end of device **10** (e.g., in region **18**) to handle 2G and 3G voice and data signals and a dual band antenna may be provided at another end of device **10** (e.g., in region **21**) to handle GPS and 2.4 GHz signals. The pentaband antenna may be used to cover wireless bands at 850 MHz, 900 MHz, 1800 MHz, 1900 MHz, and 2100 MHz (as an example). The dual band antenna **63** may be used to handle 1575 MHz signals for GPS operations and 2.4 GHz signals (for Bluetooth® and IEEE 802.11 operations). These are merely illustrative arrangements. Any suitable antenna structures may be used in device **10** if desired.

To facilitate manufacturing operations, device **10** may be formed from two intermediate assemblies, representing upper and lower portions of device **10**. The upper or top portion of device **10** is sometimes referred to as a tilt assembly. The lower or bottom portion of device **10** is sometimes referred to as a housing assembly.

The tilt and housing assemblies are each formed from a number of smaller components. For example, the tilt assembly may be formed from components such as display **16** and an associated touch sensor. The housing assembly may include a plastic housing portion **12** and printed circuit boards. Integrated circuits and other components may be mounted on the printed circuit boards.

During initial manufacturing operations, the tilt assembly is formed from its constituent parts and the housing assembly is formed from its constituent parts. Because essentially all components in device **10** make up part of these two assemblies, the finished assemblies represent a nearly complete version of device **10**. The finished assemblies may, if desired, be tested. If testing reveals a defect, repairs may be made or defective assemblies may be discarded. During a final set of manufacturing operations, the tilt assembly is inserted into the housing assembly. With one suitable arrangement, one end of the tilt assembly is inserted into the housing assembly. The tilt assembly is then rotated (“tilted”) into place so that the upper surface of the tilt assembly lies flush with the upper edges of the housing assembly.

As the tilt assembly is rotated into place within the housing assembly, clips on the tilt assembly engage springs on the housing assembly. The clips and springs form a detent that helps to align the tilt assembly properly with the housing assembly. Should rework or repair be necessary, the insertion process can be reversed by rotating the tilt assembly up and away from the housing assembly. During rotation of the tilt assembly relative to the housing assembly, the springs flex to accommodate movement. When the tilt assembly is located within the housing assembly, the springs press into holes in the clips to prevent relative movement between the tilt and housing assemblies. Rework and repair operations need not be destructive to the springs, clips, and other components in the device. This helps to prevent waste and complications that might otherwise interfere with the manufacturing of device 10.

If desired, screws or other fasteners may be used to help secure the tilt assembly to the housing assembly. The screws may be inserted into the lower end of device 10. With one suitable arrangement, the screws are inserted in an unobtrusive portion of the end of device 10 so that they are not noticeable following final assembly operations. Prior to rework or repair operations, the screws can be removed from device 10.

An exploded perspective view showing illustrative components of device 10 is shown in FIG. 3.

Tilt assembly 60 (shown in its unassembled state in FIG. 3) may include components such as cover 62, touch sensitive sensor 64, display unit 66, and frame 68. Cover 62 may be formed of glass or other suitable transparent materials (e.g., plastic, combinations of one or more glasses and one or more plastics, etc.). Display unit 66 may be, for example, a color liquid crystal display. Frame 68 may be formed from one or more pieces. With one suitable arrangement, frame 68 may include metal pieces to which plastic parts are connected using an overmolding process. If desired, frame 68 may be formed entirely from plastic or entirely from metal.

Housing assembly 70 (shown in its unassembled state in FIG. 3) may include housing 12. Housing 12 may be formed of plastic and/or other materials such as metal (metal alloys). For example, housing 12 may be formed of plastic to which metal members are mounted using fasteners, a plastic overmolding process, or other suitable mounting arrangement.

As shown in FIG. 3, handheld electronic device 10 may have a bezel such as bezel 14. Bezel 14 may be formed of plastic or other dielectric materials or may be formed from metal or other conductive materials. An advantage of a metal (metal alloy) bezel is that materials such as metal may provide bezel 14 with an attractive appearance and may be durable. If desired, bezel 14 may be formed from shiny plastic or plastic coated with shiny materials such as metal films.

Bezel 14 may be mounted to housing 12. Following final assembly, bezel 14 may surround the display of device 10 and may, if desired, help secure the display onto device 10. Bezel 14 may also serve as a cosmetic trim member that provides an attractive finished appearance to device 10.

Housing assembly 70 may include battery 74. Battery 74 may be, for example, a lithium polymer battery having a capacity of about 1300 mA-hours. Battery 74 may have spring contacts that allow battery 74 to be serviced.

Housing assembly 70 may also include one or more printed circuit boards such as printed circuit board 72. Components may be mounted to printed circuit boards such as microphone 76 for microphone port 24, speaker 78 for speaker port 22, and dock connector 20, integrated circuits, a camera, ear speaker, audio jack, buttons, SIM card slot, etc.

A top view of an illustrative device 10 is shown in FIG. 4. As shown in FIG. 4, device 10 may have controller buttons such as volume up and down buttons 80, a ringer A/B switch 82 (to switch device 10 between ring and vibrate modes), and a hold button 88 (sleep/wake button). A subscriber identity module (SIM) tray 86 (shown in a partially extended state) may be used to receive a SIM card for authorizing cellular telephone services. Audio jack 84 may be used for attaching audio peripherals to device 10 such as headphone, a headset, etc.

An interior bottom view of device 10 is shown in FIG. 5. As shown in FIG. 5, device 10 may have a camera 90. Camera 90 may be, for example, a two megapixel fixed focus camera.

Vibrator 92 may be used to vibrate device 10. Device 10 may be vibrated at any suitable time. For example, device 10 may be vibrated to alert a user to the presence of an incoming telephone call, an incoming email message, a calendar reminder, a clock alarm, etc.

Battery 74 may be a removable battery that is installed in the interior of device 10 adjacent to dock connector 20, microphone 76, and speaker 78.

A cross-sectional side view of device 10 is shown in FIG. 6. FIG. 6 shows the relative vertical positions of device components such as housing 12, battery 74, printed circuit board 72, liquid crystal display unit 66, touch sensor 64, and cover glass 62 within device 10. FIG. 6 also shows how bezel 14 may surround the top edge of device 10 (e.g., around the portion of device 10 that contains the components of display 16 such as cover 62, touch screen 64, and display unit 66). Bezel 14 may be a separate component or, if desired, one or more bezel-shaped structures may be formed as integral parts of housing 12 or other device structures.

An illustrative process for assembling device 10 from tilt assembly 60 and housing assembly 70 is shown in FIGS. 7, 8, and 9.

As shown in FIG. 7, the assembly process may begin by inserting upper end 100 of tilt assembly 60 into upper end 104 of housing assembly 70. This process involves inserting tilt assembly 60 into housing assembly 70 along direction 118 until protrusions (not shown in FIG. 7) on the upper end of tilt assembly 60 engage mating holes on housing assembly 70. Once the protrusions on tilt assembly 60 have engaged with housing assembly 70, lower end 102 of tilt assembly 60 may be inserted into lower end 106 of housing assembly 70. Lower end 102 may be inserted into lower end 106 by pivoting tilt assembly 60 about axis 122. This causes tilt assembly 60 to rotate into place as indicated by arrow 120.

Tilt assembly 60 may have clips such as clips 112 and housing assembly 70 may have matching springs 114. When tilt assembly 60 is rotated into place within housing assembly 70, the springs and clips mate with each other to hold tilt assembly 60 in place within housing assembly 70.

Tilt assembly 60 may have one or more retention clips such as retention clips 116. Retention clips 116 may have threaded holes that mate with screws 108. After tilt assembly has been inserted into housing assembly, screws 108 may be screwed into retention clips 116 through holes 110 in housing assembly 70. This helps to firmly secure tilt assembly 60 to housing assembly 70. Should rework or repair be desired, screws 108 may be removed from retention clips 116 and tilt assembly 60 may be released from housing assembly 70. During the removal of tilt assembly 60 from housing assembly 70, springs 114 may flex relative to clips 112 without permanently deforming. Because no damage is done to tilt

11

assembly 60 or housing assembly 70 in this type of scenario, nondestructive rework and repair operations are possible.

FIG. 8 shows device 10 in a partially assembled state, in which tilt assembly 60 of FIG. 7 has been rotated further in direction 120 relative to housing assembly 70 than in the state of FIG. 7.

FIG. 9 shows device 10 in a fully assembled state in which tilt assembly 60 has been mounted within housing assembly 70 and in which screws 108 have been screwed into the retention clips on tilt assembly 60. As shown in FIG. 9, holes 110 may provide a recessed region so that the ends of screws 108 do not protrude beyond the outer surface of housing 12.

A cross-sectional side view of device 10 that shows how screws 108 may pass through bezel 14 is shown in FIG. 10. As shown in FIG. 10, screw 108 may have head 124 and tip 126. During assembly, a screwdriver or other tool engages a groove or other features on head 124 to rotate screw 108 into place. Hole 110 in housing 12 may be a through hole that provides radial clearance between the outer edges of head 124 and inner walls 140 of hole 110. Hole 138 in bezel 14 may be sized so that the underside of head 124 presses against bezel 14. In particular, hole 138 may have a diameter that is small enough to allow head surfaces 144 to bear against bezel surfaces 142. This pulls bezel 14 in direction 154. Retention clip 116 may have a threaded hole 128 into which tip 126 of screw 108 may be screwed. This pulls retention clip 116 in direction 160.

When screw 108 is tightened, bezel 14 and retention clip 116 are pulled towards each other. Bezel 14 is pulled in direction 154 and retention clip 116 is pulled in direction 160, so that inner bezel surface 156 of bezel 14 and outer retention clip surface 158 bear against each other. This helps to hold device 10 together and prevents unintentional removal of the tilt assembly from the housing assembly.

Retention clip 116 may be attached to frame 68 using any suitable technique (e.g., fasteners, adhesive, etc.). With one particularly suitable arrangement, which is illustrated in FIG. 10, retention clip 116 may have an upper end with enlarged portion 132 and constricted portion 130. Retention clip 116 may be formed from a durable material such as metal. (All metal parts in device 10 may be formed from elemental metals or metal alloys.) Frame 68 may be formed at least partly from a moldable material such as plastic. At end 102, the plastic of frame 68 in region 134 may be molded over enlarged portion 132 of retention clip 116, thereby holding retention clip to frame 68.

Frame 68 may have lip-shaped protrusions such as protrusions 148. Protrusions 148 may help form a shelf for cover glass 62. In particular, protrusions 148 may form a shelf with inner surfaces 150 that hold outer edges 152 of cover 62.

A gasket such as gasket 146 may be interposed between bezel 14 and the display of device 10. In particular, gasket 146 may be used to prevent cover glass 62 from directly bearing against bezel 14. This may help to prevent rubbing between bezel 14 and cover glass 62, thereby preventing chips or scratches from forming in cover glass 62. Gasket 146 may be formed of thermoplastic urethane (TPU), silicone, polyester film, or other soft plastic (as an example). Gasket 146 may have any suitable cross-sectional shape. For example, gasket 146 may have a circular cross section, gasket 146 may have a rectangular cross-section, etc. Gasket 146 may help to seal the surface of the display portion of device 10 to prevent debris from entering device 10. Gasket 146 may also help to center the display within bezel 14 and may help to hide potentially unsightly portions of the display from view. The cover glass portion of display 16 may have

12

one or more holes or cut-away portions. For example, glass 62 may have a hole that accommodates button 19 (FIG. 1). Glass 62 may also have a hole that forms receiver port 23 (FIG. 1) to accommodate sound from a speaker.

At tilt assembly end 100, frame 68 may have one or more protrusions such as protrusion 136. These protrusions, which are sometimes referred to as teeth, tabs, or fingers, are used to hold end 100 of the tilt assembly into place within the housing assembly. As shown in FIG. 10, bezel 14 may have recesses such as hole 162 that receive teeth such as tooth 136. Holes such as hole 162 are preferably shallow enough to allow tilt assembly 60 to rotate in direction 120 as shown in FIGS. 7, 8, and 9 without damaging the teeth. Nondestructive rotation may also be facilitated by use of a curved underside portion in the teeth.

A perspective view of tilt assembly 60 is shown in FIG. 11. As shown in FIG. 11, tilt assembly 60 may include frame 68. Metal clips such as clip 112 may be mounted onto the frame (e.g., along length 164, as shown in FIG. 11).

Frame 68 may be formed of a single material (e.g., plastic or metal) or, more preferably, multiple materials. In embodiments in which frame 68 is formed from multiple materials, the weight of frame 68 may be minimized while providing sufficient structural strength where most beneficial. As shown in FIG. 12, for example, frame 68 may have a main portion formed from a molded plastic frame member 166. One or more metal members may be attached to member 166. For example, metal frame struts 168 may be attached to member 166. Any suitable attachment mechanism may be used to connect frame struts 168 to frame member 166. With one particularly suitable arrangement, plastic frame member 166 molded onto metal frame struts 168 during manufacturing. This forms an integral frame 68 having both metal and plastic parts. Additional metal parts such as clips 112 may be attached to frame struts 168. For example, clips 112 may be welded to frame struts 168 or may be attached to frame struts 168 using fasteners or adhesive. Clips 112 may be attached to struts 168 in regions such as region 164 (as an example).

FIG. 13 shows a cross-sectional side view of frame 68 taken along dotted line 170 and viewed in direction 172 of FIG. 12. As shown in FIG. 13, frame struts 168 may be connected to plastic frame member 166 to form frame 68. Frame struts 168 may have holes or other interlocking features at periodic locations along their lengths that help the plastic of frame member 166 to securely engage frame struts 168 (e.g., in engagement region 174).

Plastic frame member 166 may form a shelf that supports cover glass 62. The shelf may be formed by inner surface 150 of frame member protrusion 148 and upper peripheral frame member surface 176. An advantage of using a shelf that is formed of relatively soft materials is that this helps prevent the shelf from damaging cover glass 62. If desired, portions of gasket 146 such as gasket portion 178 of FIG. 13 may be interposed between edge 152 of cover glass 62 and shelf edge 150. This type of arrangement may provide additional cushioning and may therefore further help to prevent damage to cover glass 62. Gasket 146 may bear against bezel 14 along surface 178, which helps to prevent cover glass 62 from directly touching bezel 14.

A perspective view of an interior portion of housing assembly 70 is shown in FIG. 14. As shown in FIG. 14, bezel 14 may be mounted to plastic housing portion 12. Spring 114 may be mounted to housing assembly 70 by welding spring 114 to bezel 14 or by otherwise attaching spring 114 securely (e.g., using fasteners, adhesive, etc.). An advantage of using springs and a bezel that are formed of metal is that this

allows secure attachment mechanisms such as welds to be used to attach the springs. Satisfactory welds may be facilitated by using metals that do not have disparate properties. As an example, springs 114 may be formed from the same material or substantially the same material as bezel 14.

If, for example, bezel 14 is formed from stainless steel, springs 114 may also be formed from stainless steel. The same principle applies to clips 112 and frame struts 168. The use of the same material for clips 112 and struts 168 (e.g., stainless steel) may allow clips 112 to be satisfactorily welded to struts 168. An example of a stainless steel that may provide suitable strength for use in components such as frame struts 168 and bezel 14 is 304 stainless (e.g., $\frac{3}{4}$ hard 304 stainless). In this type of situation, it may be desirable to form clips 112 and springs 114 from 304 stainless, so that clips 112 may be readily welded to frame struts 168 and so that springs 114 may be readily welded to bezel 14. The use of $\frac{3}{4}$ hard heat-treated stainless steel allows these parts to be relatively strong while being bendable when sufficiently thin. In an illustrative configuration, frame struts 168 may be about 0.4 mm thick and clips 112 and springs 114 may be about 0.2 mm thick (as an example).

Springs such as spring 114 of FIG. 14 may be formed from elongated spring members such as spring member 180. Spring member 180 may be cut and bent to form spring prongs 182 (also sometimes referred to as spring members or springs). Spring prongs 182 may have any suitable shape. An advantage of forming spring prongs with relatively narrow widths (as measured along longitudinal housing dimension 184) is that this allows the springs to flex during assembly. There may be any suitable number of spring prongs in device 10. As an example, there may be one, two, three, four, five, or more than five spring prongs on the left and on the right sides of device 10. If desired, springs may be mounted on other portions of housing 12 (e.g., on the edge of housing 12 that lies along end 106 (FIG. 7)). An advantage of using springs and clips along the sides of device 10 is that this helps to ensure that cover glass 62 lies flush with the upper surfaces of bezel 14, giving device 10 an attractive finished appearance.

If desired, springs 114 (i.e., spring members such as spring member 180) may be used to form a support structure to which components in device 10 may be mounted. An arrangement of this type is shown in FIG. 15. As shown in FIG. 15, spring member 180 may have portions that form a bracket 186. Vibrator 92 (or other suitable components) may be attached to spring member 180 using bracket 186. In particular, screws 192 may be used to connect vibrator mounting bracket 190 to bent tip portion 188 of bracket 186 to hold vibrator 92 in place. An advantage of mounting moving components such as vibrator 92 to a metal structure such as spring member 180 is that this enhances the robustness of device 10 and makes device 10 less prone to failure.

Spring prongs 182 may flex during assembly. Following assembly, some or all of spring prongs 182 may engage clips 112 on tilt assembly 60. As shown in FIG. 16, each clip 112 may have a main elongated member 198. Elongated members such as elongated member 198 may be welded to frame struts 168 and may extend along the edge of tilt assembly 60 parallel to longitudinal dimension 200. Elongated member 198 may be substantially planar (as an example) and may have a planar surface aligned with longitudinal dimension 200 and vertical dimension 202. Portions 194 of elongated member 198 may be bent with respect to vertical dimension 202 and with respect to the planar surface defined by dimensions 202 and 200. Bending portions 194 inwardly away from the plane of elongated member 198 angles

portions 194 inwardly so that bent portions 194 are angled with respect to vertical dimension 202. This forms holes 196 that can receive protruding spring prongs 182 (FIGS. 14 and 15) when tilt assembly 60 and housing assembly 70 are connected to each other. Holes may also be formed by removing portions of elongated member 198, by bending or otherwise manipulating portions of member 198 sideways or in other directions, by bending multiple portions of member 198 within each hole, etc. The arrangement of FIG. 16 in which holes 196 have been formed by bending portions 194 down and inwards is merely illustrative.

With one suitable embodiment of tilt assembly 60, there is a member such as member 198 that forms a clip on each side of tilt assembly 60. The perspective view of FIG. 16 shows an illustrative clip 112 that has been formed on the right side of tilt assembly 60. The perspective view of FIG. 17 shows an illustrative clip 112 that has been formed on the left side of tilt assembly 60.

A lateral cross-sectional view of an illustrative device 10 is shown in FIG. 18. As shown in FIG. 18, cover glass 62 may be mounted on top of device 10. An adhesive layer such as adhesive layer 204 may be formed between cover glass layer 62 and touch sensor 64. Touch sensor 64 may be, for example, a capacitive multitouch sensor (as an example). Touch sensor 64 may be mounted above a display unit such as liquid crystal display unit 66. Display unit 66 may be mounted above frame member 206. Frame member 206, which is sometimes referred to as a "mid-plate member" may be formed of a strong material such as metal (e.g., 304 stainless steel). Frame member 206 may have vertical portions 208. Vertical portions 208 may be attached to frame struts 168 by screws, other suitable fasteners, welds, adhesive, etc. Frame member 206 helps form a rigid platform for the components (such as display unit 66, sensor 64, and cover glass 62) that are associated with the tilt assembly. In addition to providing structural support, mid-plate frame member 206 may also provide electrical grounding (e.g., for integrated circuits, printed circuit board structures, for antennas in wireless devices 44, etc.).

As described in connection with FIG. 13, frame struts 168 may be attached to frame member 166 of frame 68. For example, frame member 166 may be formed from plastic that is molded over frame struts 168 and that engages frame struts 168 in engagement region 174. Frame protrusion 148 and gasket 146 may be used to separate glass 62 from bezel 14.

Springs 114 may be welded or otherwise mounted to bezel 14. When the tilt assembly is mounted in the housing assembly as shown in FIG. 18, spring prongs 182 protrude into the holes such as holes 196 that are formed by bent portions 194 in clips 112.

A cross-sectional view of spring 114 and clip 112 is shown in FIG. 19. As shown in the cross-sectional view of FIG. 19, angled portion 194 of clip 112 forms a rigid substantially planar shelf-like member that biases the tip of spring prong 182 upwards at lower biasing point 210. Spring prong 182 is also engaged by member 198 of clip 112 at upper biasing point 216. Biasing point 210 retards movement of spring 114 and housing assembly 70 in downward direction 220 relative to tilt assembly 60. Biasing point 216 retards movement of spring 114 and housing assembly 70 in upward direction 218 relative to tilt assembly 60. Planar member 194 is oriented along axis 222 and is angled with respect to vertical dimension 202. If desired, member 194 may flex somewhat along its length and may pivot somewhat about point 224.

The flexibility of spring prongs 182, the optional flexibility of planar member 194, and the angled orientation of

planar member **194** makes the engagement arrangement formed by springs **114** and clips **112** tolerant to manufacturing deviations. For example, consider the situation in which manufacturing deviations cause spring prong **182** to be positioned where indicated by dashed outline **214** in FIG. **19**. This type of position might result, for example, from a weld location misalignment in spring **114** or in clip **112** (or both) or a deviation in the desired bend angle for member **194** or prong **182**. As a result of such misalignment, spring prong **182** presses against biasing member **194** at biasing point **212** instead of at biasing point **210**. Despite this deviation in the biasing point location from its nominal position, there will still be good engagement between spring prong **182** and clip member **198**. For example, although the lower biasing point is altered (from point **210** to point **212**), upper biasing point **216** will still generally bias clip **114** in downwards direction **220** toward its desired location. The angled orientation of member **194** and the curved shape of spring prong **182** therefore helps to accommodate manufacturing variations. The smoothly curved shape of spring prongs **182** may also help to prevent the insertion and removal process from being too harsh when engaging and disengaging the tilt and housing assemblies from each other.

If desired, alternative spring and clip arrangements may be used. An example of an alternative spring and clip configuration is shown in FIG. **20**. As shown in FIG. **20**, it is not necessary to form a bent member in clip **112**. Rather, spring prongs such as spring prong **182** of FIG. **20** may be accommodated in a hole **196** that has been formed by removing a region of metal (or other suitable material) from within elongated member **198** of clip **112**.

As shown in FIG. **21**, it is not necessary to form holes **196** in metal clips such as clips **112**. In the FIG. **21** example, holes **196** have been formed from recesses in housing **12**.

Moreover, as the example of FIG. **21** demonstrates, it is not necessary to form clips **112** on tilt assembly **60** and springs **114** on housing assembly **70**. If desired, springs **114** and spring prongs **182** may be attached to tilt assembly **60** and holes **196** (whether integral to housing **12** or whether formed from clips **112**) may be formed as part of housing assembly **70**. An advantage of forming springs **114** on housing assembly **70** (e.g., as shown in FIG. **14**) is that this reduces the likelihood that springs **114** might scratch bezel **14** during insertion of tilt assembly **60** into housing assembly **70**.

As described in connection with FIG. **15**, because springs **114** are attached to bezel **14** and thereby housing **12**, springs **114** may be used to form a mounting structure for components such as vibrator **92**. In particular, a spring such as spring **114** of FIG. **22** may be configured to form a mounting bracket **186** having a horizontal planar member **188**. During component mounting operations, fasteners such as screws **192** of FIG. **15** may be inserted into holes **226** (FIG. **22**).

When assembling device **10**, it is generally necessary to make electrical connections between components such as the components on tilt assembly **60** and housing assembly **70**. For example, electrical connections may be made between the circuitry associated with the printed circuit board structures of housing assembly **70** and the display unit and sensor in display **16**. Electrical connections may also be made between the printed circuit board circuitry and components such as the receiver speaker of port **23**, microphone **76**, speaker **78**, and a proximity sensor (e.g., a sensor that detects the presence of a human body in close proximity to device **10**). Such electrical connections may be made using a flexible circuit structure formed from a pattern of conductive traces on a flexible printed circuit substrate such as a

polyimide-based substrate (sometimes referred to as a “flex circuit”). Electrical connections should generally also be made for buttons such as volume up and down buttons, ringer on/off buttons, hold buttons, etc. Antennas in regions **18** and **21** may also be electrically connected to circuitry on the printed circuit board structures of housing assembly **70**.

Different electrical connections use different types of electrical connectors. For example, radio-frequency signals that are conveyed to and from the antennas in device **10** may be carried over transmission lines such as coaxial cable transmission lines (i.e., micro-coax). Connections in this type of radio-frequency transmission line path may therefore involve micro-coax connectors. As another example, when two printed circuit boards are joined, it may be desirable to use so-called board-to-board connectors. Flex circuits can be connected using connectors such as zero-insertion-force (ZIF) connectors. Still other connectors may be used in other contexts.

The need to make numerous electrical connections of one or more types may make assembly challenging for unskilled workers. Device **10** may therefore use a numbering system in which the connections that are to be made are numbered. The numbering system that is used may, for example, number the connections that are to be made in a preferred or required order of assembly. Instructions may be included in the interior of the device. For example, instructions may be laser-etched into a metal surface such as an electromagnetic shielding “can” that covers one or more integrated circuits on the printed circuit board structures of housing assembly **70**.

A top view of an illustrative coaxial cable connector is shown in FIG. **23**. As shown in FIG. **23**, coaxial cable **228** may be attached to coaxial cable connector **230**. Coaxial cable connector **230** may be connected to another coaxial cable, a printed circuit board, a flex circuit, an antenna, combinations of such structures, or any other suitable electrical structure.

FIG. **24** is a side view of an illustrative coaxial cable connector of the type shown in FIG. **23**. In the example of FIG. **24**, coaxial connector **230** is shown in a disconnected state. Upper portion **232** of connector **230** is connected to coaxial cable **228**. Lower portion **234** of connector **230** is mounted to electrical structures **236** such as a flex circuit, printed circuit board, etc. Traces within structure **236** such as traces **238** may be used to electrically connect lower connector half **234** of coaxial cable connector **230** to circuitry within device **10** (e.g., an antenna, a transceiver, etc.). Connector portions **232** and **234** may be interconnected during assembly as indicated schematically by dotted line **240**.

An example of a board-to-board connector is presented in connection with FIGS. **25** and **26**. As shown in FIG. **25**, board-to-board connector **242** may include an upper-half connector portion **244** and a lower-half connector portion **250**. Both the upper and lower portions of connector **242** may have numerous pins such as pins **246** on connector portion **244** and pin **248** on connector portion **250**. In the FIG. **25** example, connector **242** is disassembled, because male connector part **244** has not yet been connected to female connector part **250**. During assembly, this connection is made to interconnect electrical structures to which connector parts **244** and **250** are mounted. As shown in the FIG. **25** example, connector part **244** may be electrically connected to traces **258** in electrical structure **260** and connector part **250** may be electrically connected to traces **250** in electrical structure **254**. Structures **260** and **254** may be printed circuit boards.

A top view of board-to-board connector **242**, which presents an illustrative layout for pins such as pints **246** and **248** is shown in FIG. **26**.

Board-to-board connectors such as connector **242** of FIGS. **25** and **26** may be used whenever it is desired to electrically interconnect structures such as printed circuit boards (e.g., when they are mounted on top of each other). Because there are typically numerous pins in a board-to-board connector such as a printed circuit board, the use of a board-to-board connector may be preferable to using wires or cables to make a connection. Moreover, unlike hardwired solder connectors, board-to-board connectors may be readily disconnected when desired for rework or repair.

Flex circuits may be used to form connections between different parts of device **10**. Flex circuits have advantages over conventional parallel bus wires such as reduced size and weight. Flex circuits may also be less expensive to manufacture in large quantities than other types of interconnects and provide geometric flexibility when designing and assembly complex structures. In a typical arrangement, a flex circuit might be attached at one end to a series of components (e.g., dock connector **20**, acoustic components, sensors, etc.). At the other end, the flex circuit may need to be connected to circuitry on a printed circuit board. This type of connection may be formed using a socket-type connector that is configured to receive a flex circuit (sometimes referred to as a zero-insertion-force or ZIF connector).

A top view of an illustrative flex circuit **262** and zero-insertion force flex circuit connector **264** is shown in FIG. **27**. During assembly, flex circuit **262** is inserted into connector **264** in direction **266**. This causes exposed traces **268** in region **274** to electrically connect with mating conductors **270** in region **272** of connector **264**. As shown in the side view of FIG. **28**, connector **264** may have a lever **276** that may be actuated by pressing downwards in direction **278**. When lever **276** is pressed downwards in this way, the pins of connector **264** engage the flex circuit traces of flex circuit **262** and form a solid set of electrical connections.

The connector types shown in FIGS. **23-28** are merely illustrative. Device **10** may use one, two, three, or more than three different types of connectors in interconnecting its electrical components. Some or all of these connectors may, if desired, be non-destructive connectors having mating parts that can be disconnected if desired for rework or repair operations. An advantage to using connectors that can be repeatedly connected and disconnected is that this may reduce waste in the event of a rework or repair.

Particularly in assembly environments in which there are numerous connections that need to be made, assembly operations may be challenging for unskilled workers who are unfamiliar with the assembly process. Device **10** may therefore include a set of numbers to help guide workers during the assembly process. An example of this type of arrangement is shown in FIG. **29**.

FIG. **29** shows an illustrative interior view of device **10**. As shown in FIG. **29**, device **10** may include components such as integrated circuits encased in electromagnetic shielding ("cans") such as housings **280** and **282**. Device **10** may also include one or more modules such as module **284**. Module **284** may be, for example, a module that includes acoustic components such as a microphone, speaker, etc. Dock connector **20** may be connected to a module such as module **284**.

Regions such as regions **286** and **288** may include exposed circuit boards, one or more discrete components, flex circuits, or other suitable electrical components.

The components of device **10** may be interconnected by communications paths. The communications paths may be, for example, transmission line paths such as coaxial cable paths, flex circuits, board-to-board paths supported by printed circuit board traces, etc., as described in connection with FIGS. **23-28**. An illustrative communications path is shown as path **292** in FIG. **29**.

As shown in FIG. **29**, assembly order indicators such as numbers **290** may be formed on device **10**. The assembly order indicators may be provided in the form of any suitable markings that indicate a preferred or required order of assembly for the connectors that are used in interconnecting the electrical components of device **10**. Examples of suitable indicators include Arabic numerals (e.g., 1, 2, 3, . . .), Roman numerals, Chinese numerals, letters (e.g., A, B, C . . . or comparable letters in other alphabets), combinations of numerals and letters (e.g., A1, A2, B1, B2, B3, C1, . . .), or symbols (e.g., *, **, ***, etc.). The indicators preferably denote a desired assembly order or orders and may, if desired, be followed in reverse order by a worker who wishes to partly or fully disassembly a device for rework or repair.

To assist workers in deciphering the assembly/disassembly order indicators and/or to provide other suitable guidance for the workers, device **10** may include instructions such as instructions **294**. Instructions **294** may be laser-etched on the metal surface of cans such as can **280**, may be printed on can **280** or other suitable surface of the components of device **10**, may be printed on a label that is affixed within device **10**, may be inscribed on an interior portion of case **12**, or may be otherwise formed on device **10**. Assembly and disassembly instructions (e.g., instructions referring to the assembly order) may also be included in software and displayed using display **16**, although this type of arrangement will generally only be practical if device **10** is at least partly operational).

Instructions **294** may be written instructions that include, for example, explanatory text (e.g., in English, Chinese, or other suitable language). Instructions **294** may also be partly or completely formed from symbolic instructions (e.g., a diagram showing how parts should be connected, a list of corresponding assembly order indicators, etc.). Instructions **294** may, if desired, include information on the proper use of device **10**, legal notices, etc.

The foregoing is merely illustrative of the principles of this invention and various modifications can be made by those skilled in the art without departing from the scope and spirit of the invention.

What is claimed is:

1. A wireless communications device having opposing front and rear faces, comprising:
 - an antenna configured for cellular telephone communications;
 - a housing having a dielectric portion and a metal portion, wherein the metal portion forms part of the antenna and wherein the dielectric portion comprises glass and forms at least part of the rear face of the wireless communications device;
 - a display having and a cover glass and a capacitive touch sensor that detects touch input on the cover glass, wherein the cover glass has an opening and wherein the metal portion of the housing surrounds the display and couples the display to the dielectric portion of the housing; and
 - a speaker port in the housing between the front and rear faces.

19

2. The wireless communications device defined in claim 1 wherein the capacitive touch sensor comprises a multi-touch capacitive touch sensor.

3. The wireless communications device defined in claim 2 wherein the opening forms a speaker port.

4. The wireless communications device defined in claim 1 further comprising a microphone port in the housing between the front and rear faces.

5. The wireless communications device defined in claim 4 further comprising a data port in the housing between the front and rear faces.

6. The wireless communications device defined in claim 1 wherein the display forms part of a first assembly having a clip and the housing forms part of a second assembly having a spring that engages the clip.

7. The wireless communications device defined in claim 6 further comprising screws that screw into the first assembly through the second assembly.

8. The wireless communications device defined in claim 1 further comprising a button disposed within the opening.

9. The wireless communications device defined in claim 1 wherein the capacitive touch sensor is adhered to the cover glass.

10. The wireless communications device defined in claim 1 further comprising a gasket interposed between the display and the housing.

11. The wireless communications device defined in claim 10 further comprising:

a frame that supports the cover glass, wherein the frame has a plastic portion and a metal portion.

12. The wireless communications device defined in claim 10 wherein the plastic portion is molded onto the metal portion, wherein the plastic portion forms a shelf that supports the cover glass, and wherein the metal portion forms a frame strut.

20

13. The wireless communications device defined in claim 12 further comprising a clip attached to the frame strut.

14. The wireless communications device defined in claim 12 wherein the plastic portion has a protrusion and wherein the gasket is located between the protrusion and the cover glass.

15. An electronic device, comprising;
a display having a capacitive touch sensor;
a glass cover layer overlapping the display;
a glass rear housing member; and
a metal peripheral member coupled between the cover glass layer and the glass rear housing member.

16. The electronic device defined in claim 15 wherein the metal peripheral member has at least one opening.

17. The electronic device defined in claim 15 wherein the display comprises an organic light-emitting diode display.

18. The electronic device defined in claim 15 wherein the metal peripheral member forms part of an antenna.

19. An electronic device having front and rear faces, comprising:

first and second glass members that respectively form at least a portion of the front and rear faces;
an organic light-emitting diode display having a capacitive touch sensor, wherein the organic light-emitting diode display emits light through the first glass layer;
an antenna configured for cellular communications; and
a conductive member that at least partially surrounds the organic light-emitting diode display, wherein the conductive member is coupled between the first and second glass members and forms part of the antenna.

20. The electronic device defined in claim 19 wherein the conductive member has a speaker port opening and a data port opening.

* * * * *